# TOPOGRAPHY OF KENTUCKY

WILLARD ROUSE JILLSON

*The*

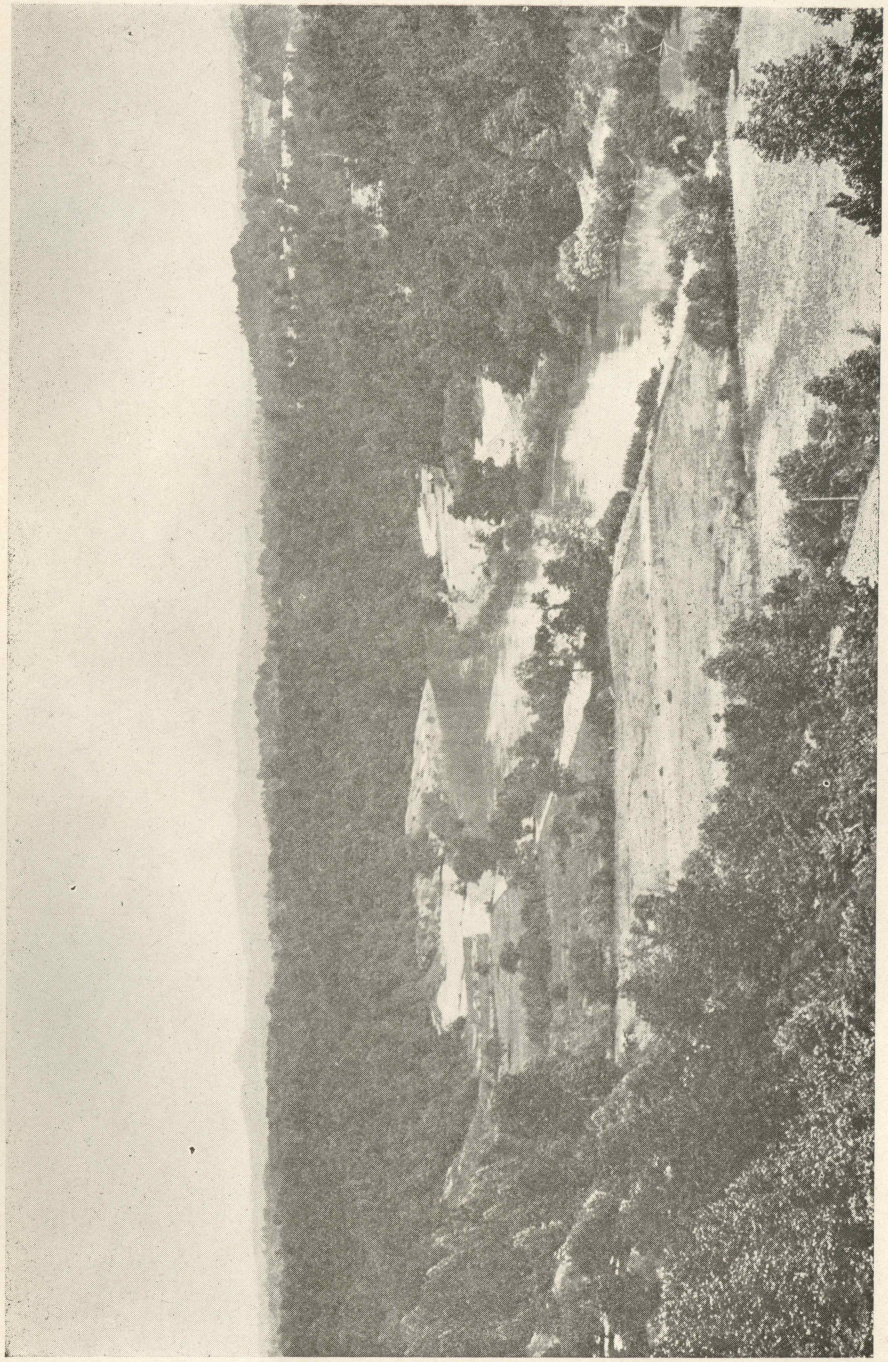
# *Kentucky Geological Survey*

WILLARD ROUSE JILLSON
DIRECTOR and STATE GEOLOGIST

SERIES VI
VOLUME THIRTY

## *Topography of Kentucky and other papers*

*1927*



THE MEANDERING CUMBERLAND

This valley is quite typical of the entrenched meandering mountain streams of Kenutcky. The view presented here may be seen just below Williamsburg in Whitley County. It is characteristic topographically of this part of the Cumberland Plateau.

# *The* TOPOGRAPHY *of* KENTUCKY

A systematic study and classification of all the prominent physical features of Kentucky coupled with an indexed collection of twenty-four separate papers on the geology and mineral resources of the Commonwealth


*By*

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AND
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*Illustrated with One Hundred Thirty-one Photographs, Maps and Diagrams*


THE KENTUCKY GEOLOGICAL SURVEY
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*Dedicated to the Memory of*

ROLLIN D. SALISBURY
SAMUEL WENDELL WILLISTON
JOSEPH BARRELL *and*
STUART WELLER

*Eminent Geologists,*
*Teachers and Friends*
*of my youth.*

# *Table of Contents*


| | | Page |
|---|---|---|
| Preface | | V. |
| Contents | | VI. |
| Illustrations | | VII. |
| Chapter I. | The Topography of Kentucky | 1 |
| Chapter II. | An Isothrustic Hypothesis | 61 |
| Chapter III. | Unique Devonic Sandbar | 71 |
| Chapter IV. | Fault Pattern of Kentucky | 77 |
| Chapter V. | New Relief Map of Kentucky | 81 |
| Chapter VI. | Kentucky Cannel Coals | 83 |
| Chapter VII. | Primeval Tracts in Kentucky | 87 |
| Chapter VIII. | Kentucky Rock Asphalt | 95 |
| Chapter IX. | Outlook for Mineral Development in Kentucky | 105 |
| Chapter X. | American Karst Country | 111 |
| Chapter XI. | Glacial Pebbles in Eastern Kentucky | 123 |
| Chapter XII. | Glaciation in Eastern Kentucky | 127 |
| Chapter XIII. | Early Glaciation in Kentucky | 137 |
| Chapter XIV. | Agricultural Perspective of Kentucky Geology | 143 |
| Chapter XV. | Administrative Report for the (Sixth) Kentucky Geological Survey—Years 1924 and 1925 | 173 |
| Chapter XVI. | State Parks in Kentucky | 221 |
| Chapter XVII. | Natural Resources of Kentucky | 231 |
| Chapter XVIII. | Unused Natural Wealth—An Opportunity | 235 |
| Chapter XIX. | Major Drainage Modifications of Big Sandy River | 241 |
| Chapter XX. | The Ashland Gas Field | 245 |
| Chapter XXI. | Fire Clays of Northeastern Kentucky | 249 |
| Chapter XXII. | The Clays of Kentucky | 255 |
| Chapter XXIII. | Governor Powell's Recommendations to the Legislature Relative to the Establishment of the First Kentucky Geological Survey | 267 |
| Chapter XXIV. | Valley-Filled Areas of Western Kentucky Coal-Field | 271 |
| Chapter XXV. | Geology of the Oil Shales of the Eastern United States | 275 |


# *Preface*

The physical features of Kentucky—always changing in panorama, always interesting to the traveler, and always thrilling to the native son homeward bound—have received less from the pen of the geologist and the engineer than they deserve. While an adequate discussion of the Topography of Kentucky, detailed in every necessary particular could hardly be compressed within the covers of this volume—much less these few leading pages—it is hoped that the reader will find the material here presented comprehensive in outline and accurate in interpretation. Illustrative features have been carefully chosen to depict type conditions.

A study of the topographic maps referenced in this volume will aid in a better understanding of the text, which it may be interesting to note in passing, represents the accumulated experience of ten consecutive years of professional geological investigation in all parts of Kentucky.

There are also presented here twenty-four separate papers discussing independently almost as many subjects relative to the geology and mineral resources of Kentucky. These papers are, for the most part, reprints of articles which have been written by the State Geologist and published during the last few years in various geological and other Journals. Their subject matter, affording much that is new in treatment and fact in the specialized field of Kentucky geology, should be of both present and permanent value

W. R. Jillson

Director and State Geologist.

Old State Capitol
Frankfort, Kentucky.
December 1, 1927.

# *List of Illustrations*


| | | Page |
|---|---|---|
| 1. | The Meandering Cumberland | Frontispiece |
| 2. | The Cumberland Plateau | 1 |
| 3. | Youthful Topography of the Kentucky River Gorge | 2 |
| 4. | Cavern in Mammoth Cave Region | 3 |
| 5. | Ohio River Lowlands | 5 |
| 6. | Natural Bridge in Powell County | 7 |
| 7. | Youthful Stream and Mature Topography | 8 |
| 8. | Topographical Aspect of Late Youth | 9 |
| 9. | Mature Topography in Morgan County | 10 |
| 10. | An Area of Mature Dissection | 11 |
| 12. | Broad Undulations near Hickman | 15 |
| 13. | Reelfoot Lake Topography | 17 |
| 14. | Typical Knob-Belt Hill | 18 |
| 15. | Mature Topography and Anticedent Stream: "Breaks of Sandy" | 20 |
| 16. | Knobs Topography near Panola, Kentucky | 21 |
| 17. | Kentucky River Gorge Topography | 23 |
| 18. | Features of Old Age in Land Form | 26 |
| 19. | The Cumberland Mountain | 27 |
| 20. | Ridge Cliffs and Entrenched Meanders | 29 |
| 21. | Stream Adjustment in Southeastern Kentucky | 30 |
| 22. | Flat V-Shaped Valleys | 31 |
| 23. | A Giant Subterranean Passage | 32 |
| 24. | Topography of Karst Area near Bowling Green | 34 |
| 25. | Entrenched Meanders of the Kentucky River | 35 |
| 26. | An Abandoned Meander in Elkhorn Creek, Franklin County | 37 |
| 27. | The Pineville Gap | 39 |
| 28. | Topographical Expression of the Pine Mountain Fault | 40 |
| 29. | A Remarkable Hanging Valley | 42 |
| 30. | Karst and Hill Land Topography | 45 |
| 31. | Index to Reconnaissance Topography in Kentucky | 46 |
| 32. | Recent Topographic Surveys | 49 |
| 33. | The "Big Spring" | 50 |
| 34. | The Golconda Plateau | 53 |
| 35. | Variable Rock Hardness Expressed in Topography near Princeton, Caldwell County | 54 |
| 36. | Lower Gorge of Cumberland River | 55 |
| 37. | Unmapped Embayment Topography | 56 |
| 38. | Topography of Kentucky | 48 |
| 39. | Geology of the Eastern United States | 63 |
| 40. | Geology of the Ohio Valley Isothrusts | 66 |
| 41. | Harpeth River at Mouth of Dog Creek | 72 |
| 42. | Junction of Hardin Sandstone and Fore Payne Formation | 74 |

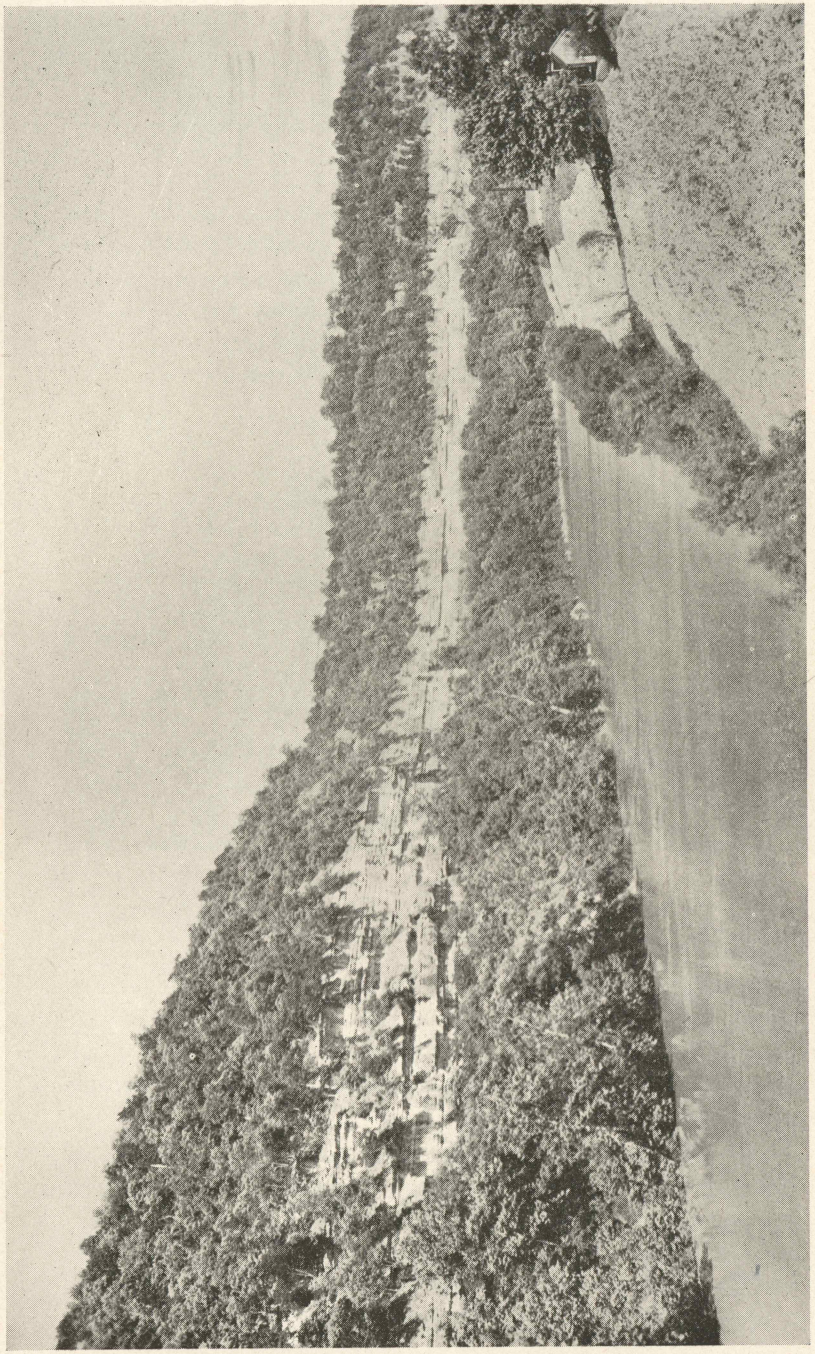




| | | |
|---|---|---|
| 43. | Cheatham Co., Tenn. Unconformity West of "A" | 74 |
| 44. | Pegram Limestone near Pegram Devonic Sandbar in Tennessee | 76 |
| 45. | Sketch Showing Fault Pattern in Kentucky | 78 |
| 46. | New Relief Map of Kentucky | 82 |
| 47. | Location of Cannel Coal Deposits in Kentucky | 84 |
| 48. | Stalactites in Mammoth Cave Region | 87 |
| 49. | Cumberland Falls, from the Gorge | 90 |
| 50. | Natural Bridge, Wolfe County | 93 |
| 51. | Chester Asphalt Bleached by Sun's Rays | 95 |
| 52. | Map of Rock Asphalts of Kentucky | 97 |
| 53. | Cypress Sandstone, Big Clifty Creek | 98 |
| 54. | Interior of Old Federal Asphalt Mine | 99 |
| 55. | Rock Asphalt Mill on Green River | 100 |
| 56. | Rock Asphalt Mill, Summit | 102 |
| 57. | Rock Asphalt Quarry at Summit | 103 |
| 58. | Karst and Sink Hole Tracts in Kentucky | 112 |
| 59. | Topography Around Glasgow Junction | 113 |
| 60. | "Lost River" Disappearing near Bowling Green | 114 |
| 61. | Open Sink Hole near Dripping Springs Escarpment | 116 |
| 62. | Mammoth Cave Region | 117 |
| 63. | "Onyx Chamber" Great Crystal Cave | 118 |
| 64. | Great Onyx Cave | 119 |
| 65. | Ponded Sink Hole near Bowling Green | 120 |
| 66. | Some Kentucky Glacial Pebbles and Boulder Fragments | 125 |
| 67. | Topography in the vicinity of the Epworth Boulder | 127 |
| 68. | Illinois Glacial Boundary and Location of Erratics in Eastern Kentucky | 128 |
| 69. | Some Fragments of Epworth Boulder | 130 |
| 70. | Excavation of Portion of Epworth Boulder | 131 |
| 71. | Side View of Farmers Boulder | 133 |
| 72. | End View of Farmers Boulder | 134 |
| 73. | Excavation of Epworth Boulder | 134 |
| 74. | Early and Illinoian Glaciations in Kentucky | 138 |
| 75. | Soil Formation in Kentucky | 145 |
| 76. | Blue Grass Hempfield, Fayette County | 146 |
| 77. | Lexington Plateau | 148 |
| 78. | Knobs Features | 150 |
| 79. | Karst Region, Mississippian Plateau, Warren County | 152 |
| 80. | Mountain Farms near Williamsburg | 154 |
| 81. | Kentucky Mountains | 156 |
| 82. | Ohio River Bottoms near Owensboro | 160 |
| 83. | Ohio Lowland | 162 |
| 84. | "Black Patch" in "Purchase" Region | 164 |
| 85. | The Louisville Plain | 166 |
| 86. | The Mississippian Plateau | 168 |
| 87. | The Knobs Escarpment above Irvine | 170 |
| 88. | Publications of the (Sixth) Geological Survey | 172 |

89. Index to Areas Mapped Structurally ..... 179
90. Index to Field Work ..... 185
91. Resolution of State Highway Commission Relative to Co-operative Mapping ..... 202
92. Outcrop of Devonian Oil Shale ..... 210
93. Rock Asphalt Quarry, Edmonson County, Ky. ..... 216
94. Index Map to Surveyed Topography in Kentucky ..... 218
95. The Capitol at Frankfort ..... 221
96. Natural Bridge ..... 222
97. Boulder in Cumberland Gorge ..... 224
98. The Star Chamber ..... 226
99. Meeting of the Waters ..... 228
100. Cumberland Falls ..... 230
101. Big Sandy in Cumberland Plateau near Pine Mountain ..... 241
102. Past and Present Big Sandy Drainage Areas ..... 242
103. Middle Big Sandy near Prestonsburg ..... 243
104. Upper Licking River near Grassy Creek ..... 244
105. Typical Topography of Low Rounded Hills ..... 245
106. Salt Sand Gasser, 3,500,000 cubic feet ..... 245
107. Cross-bedded Mahoning Sandstone. Conemaugh ..... 246
108. Old Producing Gas Well, Ashland District ..... 246
109. "Big Injun," "Berea," and Ohio Shale Gas ..... 247
110. Eastern Kentucky Flint Fire Clay Field ..... 248
111. Louisville Fire Brick Works, with Daily Output of 50,000 ..... 249
112. Hayward Plant of Ashland Fire Brick Co. ..... 250
113. Olive Hill Plant ..... 252
114. Eastern Kentucky Fire Brick Plant ..... 254
115. A Jackson Purchase Claypit ..... 256
116. A Carter County Fire Brick Plant ..... 257
117. Brick Yard and Kiln ..... 259
118. Old Hand Pottery at Bybee, Kentucky ..... 260
119. Fire Brick Plant, Hitchens, Carter County. Ky. ..... 262
120. Interior of Old Hand Pottery in Madison County ..... 264
121. Map of Western Kentucky Coal Field ..... 272
122. The Chattanooga (Devonian) Shale ..... 274
123. Outcrop of Devonian Black Shales ..... 276
124. Devonian Shale, Bullitt County, Kentucky ..... 278
125. Topography of Devonian Outcrop ..... 279
126. Devonian Shale in Tennessee ..... 280
127. Oil Shale, Powell County, Kentucky ..... 281
128. Weathered Exposure Chattanooga Shale ..... 282
129. Devonian Shale in Indiana ..... 284
130. Devonian Shale Belt Topography ..... 286
131. Oil Shale near Junction City, Kentucky ..... 290

# *The* TOPOGRAPHY *of* KENTUCKY



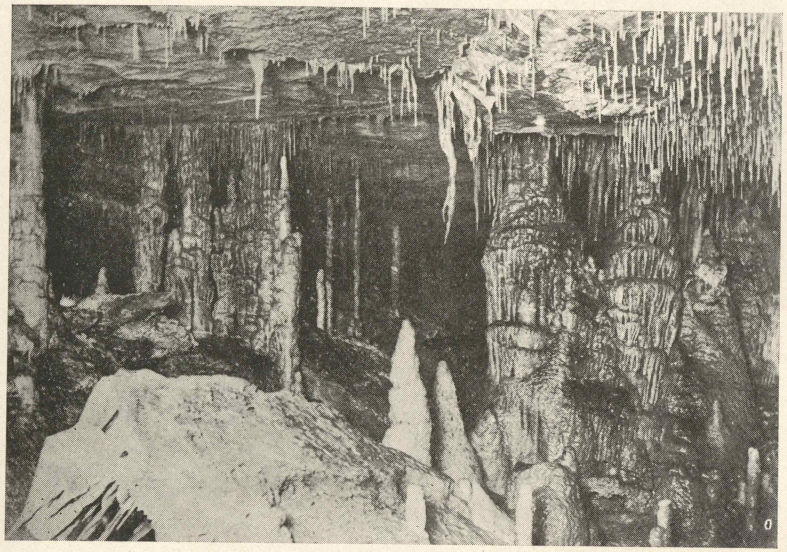
YOUTHFUL TOPOGRAPHY OF THE KENTUCKY RIVER GORGE

For a distance of seventy-five miles or more this master stream of the Bluegrass slips quietly along beneath almost perpendicular cliffs of Ordovician limestone 200 to 300 feet high. This kind of topography is typical of the region centering about Brooklyn Bridge, Mercer, Jessamine and Woodford Counties.



in degree with the distance and beauty of the expanding panorama. Love of the scenic in nature is truly age old and world wide. Savagery and civilization find common ground at the mountain top.

Interest in any prospect of the earth's surface, however, may be heightened by some knowledge of those geologic factors which have been responsible for the varying aspect of the terrain. Physical forms which to the untrained eye present in most



CAVERN IN MAMMOTH CAVE REGION

This view is in the Great Onyx Cave but there are many such in Edmonson, Warren and Barren Counties.

cases little more than the unexpected or the unusual in sculpture or color, in the light of origin and erosional modification take on a distinct and added attraction. The broad, low prairie hillock becomes a mound whipped up by slow spiralous currents perhaps in an extinct glacial lake. Clifted mountain ridge may become the ragged edge of a gigantic crustal break or fault. The volcanic cone truncated and furrowed by the beveling hand of all the weathering agencies, reassumes its towering importance above the rugged timbered hill land surrounding a re-created earth vent, fire capped and seismic reminiscent of Tertiary and Cretaceous time. The stair-step terraces and alluviated

flats tell of old lakes and rivers, while curious angulations of stream courses and an occasional headwater marsh reveals great piracies of drainage, some of which are still progressing beneath our very eyes. Even the lowly sand dunes, sometimes forest covered, mark the shore lines of glacial seas and ancient oceans long since abandoned.

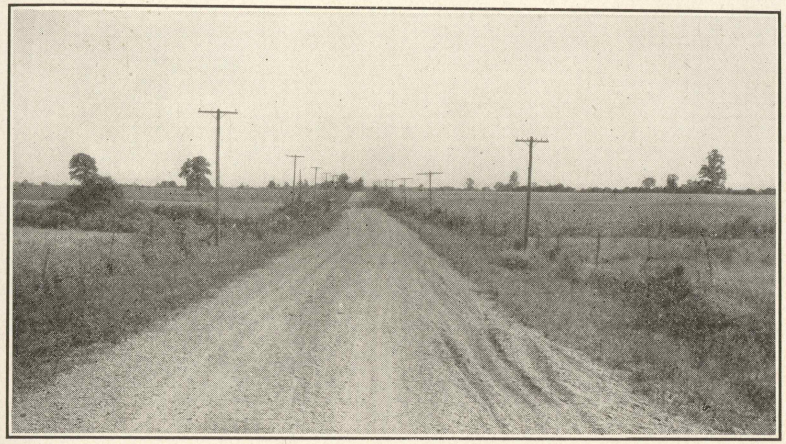
In Kentucky—a very old land surface—a great variety of physical features present themselves at every hand. This characteristicc of the terrain of the Bluegrass State gives it its distinctive charm to both the naturalist and casual traveler. While the eastern portion of the great Mississippi river basin certainly cannot boast of towering peaks such as those of the high Rockies, nor of graceful lake and ocean coast lines such as those of many other parts of the United States, it can exhibit a detail of sculpture that is none the less interesting. Indeed, in Kentucky there is so much landscape to rivet the attention of the observer that the unfolding vistas as one progresses in almost any direction seem each to present special and distinctive charm. And here the physiographer if he be used to either coastal plain or prairie country of relatively simple explanation, will find absorbing interest in unravelling the nice adjustments of repeated uplift and depression as revealed principally in the hard sediments of the Paleozoic era.

## Wind Erosion

*River Bottom Dunes*: Sand dunes, the commonplace physical features of all arid country deserts, and many ocean and lake shore lines, are only encountered occasionally in interior areas of medium or high humidity. For this reason Kentucky exhibits relatively few hillocks of sand, none of which are at the present time in movement as is so characteristically the case in many other localities. A climate featured by an intermittent precipitation, rather considerable in the aggregate throughout the year, has produced in this latitude a variegated vegetation sufficiently dense to nullify the normal work of the wind in sandy areas.

The fact that sand dunes do exist in Kentucky principally along the Ohio and Mississippi Rivers is certainly suggestive that they were whipped up under climatic, geologic and ecologic conditions quite different from the present. Since the geological age of these dunes—all of low figure, scarcely exceeding thirty or forty feet and usually much less—is comparatively recent, their period of origin is ascribed to the late Pleistocene when climatic conditions bordering upon a not far distant continental ice sheet would have assuredly been unfavorable to any very considerable dense vegetation. Prevailing westerly and southwesterly winds sweeping unobstructedly across vast areas of melting ice during even brief dry periods would certainly have picked upon and carried for great distances much rock dust and sand. The close of the glacial period must logically have witnessed the rather rapid northward advance of the normal broad leaf vegetation which it can be assumed soon effectually blanketed the source of the sand and loess and arrested the further accumulation and movement of Kentucky's river side sand dunes.





OHIO RIVER LOWLANDS

This featureless plain is characteristic of regions between Henderson and Morganfield, Kentucky.

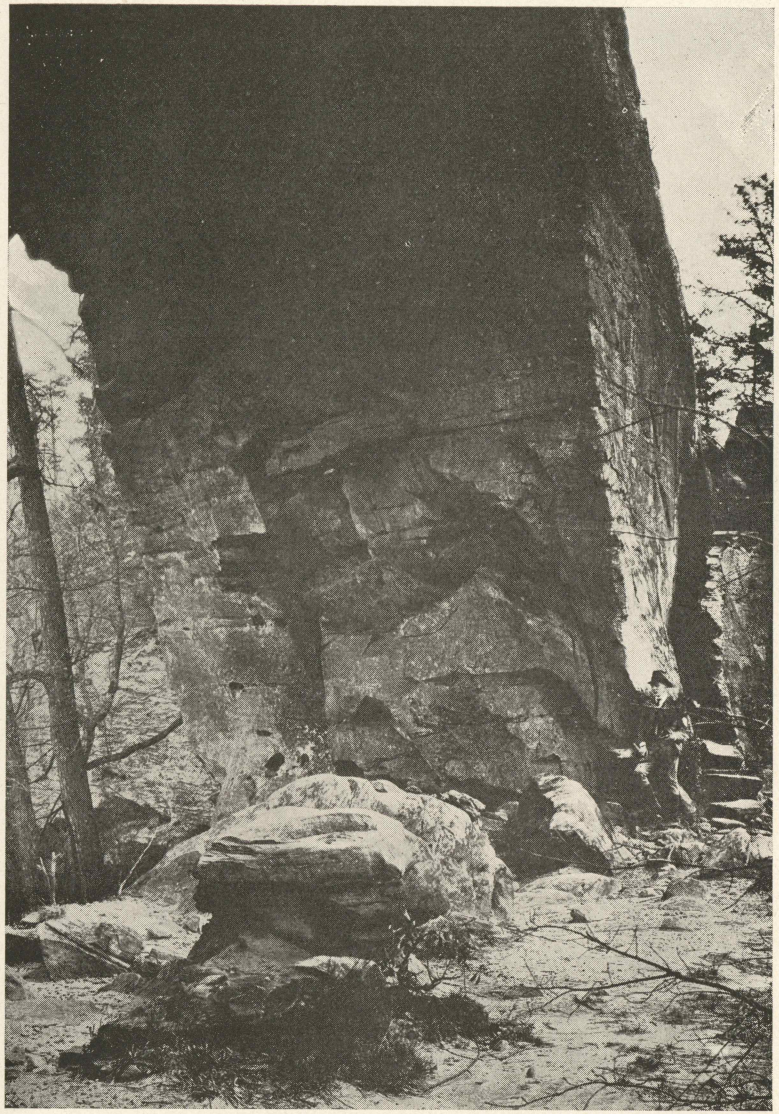
The configuration of sand dune topography in Kentucky is neither remarkable nor striking, so isolated and occasional are these unconsolidated features of the landscape. The student will find it necessary to search for them carefully in reviewing any set of Kentucky topographic sheets. Their generally low, elongate contour is frequently the only regional feature of significance on the broad, flat, poorly drained river flood plains,

and if this be borne in mind it will lead to a more rapid detection than otherwise. Two or three dunes may be seen on the prospect sheet, one forty feet high about a mile south of the mouth of Taylor creek, and two about a mile north of the lower waters of Harrods creek. The Louisville sheet shows one near the Ash Bottom road, and one near the Southern Ditch about five or six miles south of the city. The Kosmosdale sheet shows several dunes and a number of sand ridges, a physical feature more rare, between Meadow Lawn and Maplewood on either side of the 18th Street road.

Other sheets showing wind blown sand dunes are the Owensboro, Henderson, Newburg, Smithland, Paducah, Mound City, and Reelfoot Lake. The latter exhibits some rather good lake dunes, but as is the case with nearly everything pertaining to Reelfoot lake, they are a little south of the Kentucky State line in Tennessee. The unpublished Hickman and Bayou quadrangles when eventually completed will exhibit some rather good instances of river flood plains sand dunes, now more or less immovable here or elsewhere in Kentucky because of a limited supply of sand and a dense growth of vegetation supported by a very humid climate.

*Pedestal Rocks and Natural Bridges*: It is not altogether impossible that the turreted and clifted Mississippian limestone and Pennsylvanian sandstone conglomerates seen as conspicuously capping the knobs along the serrated western escarpment of the Cumberland plateau may have been shaped to some degree by wind blown sands during the late Pleistocene. The Beattyville, London and Williamsburg sheets exhibit many striking examples of this type of topographical feature. While no dunes of sand occur in these areas much loose sand is present and still somewhat in movement. Occasional pedestal rocks occur such as the one at Natural Bridge State Park in Powell County. These unique and interesting balanced remnants of once continuous clastic sediments are so pronounced as to suggest wind work in the late Pleistocene, followed, of course, by frost action in Recent times. Were wind work to have played a part in the castellation of the ridges of this part of Kentucky during the late Pleistocene, it certainly would have been an important factor in helping to form some of the remarkable natural rock bridges of this part of the State. While wind blown sand is evi-





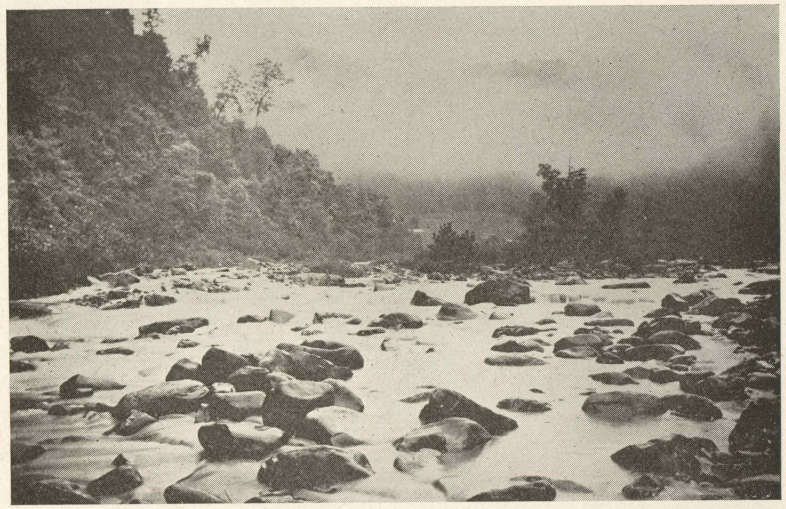
NATURAL BRIDGE IN POWELL COUNTY

There are several rock arches in this part of Kentucky including this great sandstone structure which is now a State Park. Only one-half of this arch is shown here. The writer stands in left foreground.

dently an important agent operating to enlarge these ridge bridges at the present time as anyone who has visited them will readily affirm, the importance of frost must not be discounted.

### Stream Erosion

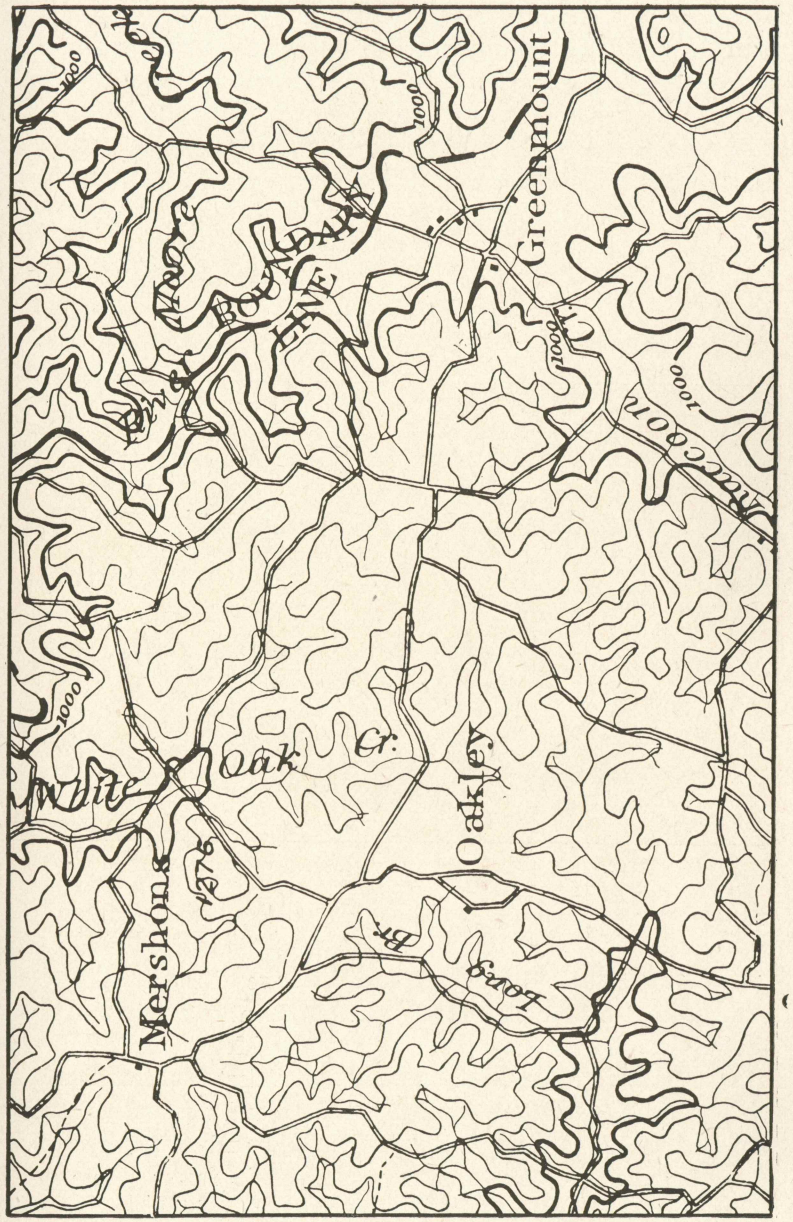
*Youth*: There are a few areas in Kentucky which illustrate advantageously very youthful topography. The best types are to be found in restricted areas within the central northern Bluegrass area. Examples may be cited on the Richmond quad-



YOUTHFUL STREAM AND MATURE TOPOGRAPHY

The view is upstream on Russell Fork of Big Sandy River near "The Breaks."

rangle in the vicinity of Richmond, and again in the northern part of this sheet in the vicinity of Winchester. Similar examples may be found on the Georgetown quadrangle in the vicinity of Versailles and Lexington, and on the Lexington quadrangle in the vicinity of Lexington. In these localities the original upland limestone plain of Tertiary age is still well defined at elevations ranging from 950 to about 1000 feet. While broadly undulating, these areas have not been dissected by surface drainage to any appreciable extent, though in the vicinity of both Lexington and Versailles, subterranean stream courses have resulted in developing sink hole or "Karst" topography of



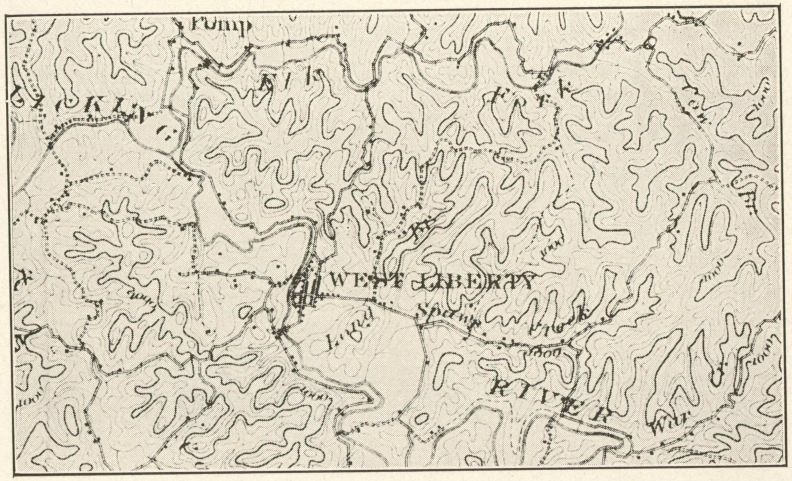

TOPOGRAPHICAL ASPECT OF LATE YOUTH

This quadrant from the central eastern part of the London quadrangle (1:125,000) is enlarged about 80%. It shows a portion of the old Cumberland plateau in Laurel and Jackson counties, still maintaining rather broad ridges. These have been identified with the Cretaceous peneplain. The contour interval is 100 feet.

well defined local character. The unpublished Springdale and Maysville quadrangles well illustrate undissected youthful Tertiary limestone uplands bordering the Ohio River.

A good example of youthful topography bordering a single river valley is seen in the area adjacent to the Rockcastle on the London quadrangle. Here we have the first entrenchment of a pronouncedly elevated structural plain.

*Maturity*: Practically all of the topography in Kentucky is mature, and it is therefore difficult to select any particular group of quadrangles which are more typically illustrative of




MATURE TOPOGRAPHY IN MORGAN COUNTY

this type of topography than many others. In a broad way the Beattyville, Williamson, Williamsburg, Whitesburg, and Troublesome quadrangles are representative of the maturely dissected Cumberland plateau of Eastern Kentucky, that part of the State commonly referred to as "the Mountains." In the Bluegrass region the Lockport and Frankfort quadrangles best show mature conditions, while in southern and western Kentucky the Scottsville, Spring Lick, Providence, and Golconda quadrangles aptly illustrate mature topographic forms. The complete list of quadrangles in Kentucky exhibiting mature topography is as follows:

**Beattyville, Big Stone Gap, Bowling Green, Brownsville, Buckhorn, Byrdstown, Calhoun, Cave-in-Rock, Central City, Cincinnati E. & W.,**

AN AREA OF MATURE DISSECTION

There is presented here the topography of an area in the Eastern Kentucky coal field just north of Jackson, Breathitt County. The drawing is an enlarged reproduction of a part of the southwestern quadrangle of the Salyersville sheet, the scale of which is 1:125,000. The contour interval is 100 feet. Ridge tops reduced to a minimum mark the Cumberland plateau. Settlements are located in and roads traverse the bottoms.

Clintwood, Cornettsville, Cub Run, Cumberland Gap, Dawson Springs, Drakesboro, Dunmore, Earlington, Frankfort, Golconda, Greenup, Harlan, Harold, Harrodsburg, Hartford, Hindman, Hurley, Hyden, Inez, Ironton, Kenova, Kosmosdale, Leitchefild, Lilly Dale, Little Muddy, Lockport, London, Madisonville, Manchester, Middlesboro, Monticello, Mt. Eden, Naugatuck, Newburg, Nolandsburg, Nortonville, Paducah, Pantsville, Pikeville, Pound Quadrangle, Prestonsburg, Princeton, Providence, Regina, Salyersville, Scottsville, Smithland, Spring Lick, Sutherland, Taylorsville, Tell City, Tompkinsville, Troublesome, Whitesburg, Whitesville, Williamsburg, Williamson.

*Old Age*: Because of its dominantly mature topography, there are only a few restricted areas within Kentucky wherein conditions of old age are exemplified in topographical figure. The Uniontown, Paducah, Owensboro, and New Haven quadrangles show small areas that have fully reached local base level. The Henderson quadrangle exhibits a considerable area which is in its old age. The same may be said though in lesser degree for the Newburg and Sutherland sheets. All of these areas in Kentucky exhibiting old age are involved by the depressional influence of the regional structure of the Western Kentucky coal field. In this area a broad subsidence to the extent of 150 to 175 or more feet has resulted in ponding drainage back upon itself. The resulting broadly alluviated areas dating probably from the late Pliocene, serve to accentuate the appearance of old age in the land forms. Had it not been for this feature of structural depression of rather wide regional significance, this area would exhibit no old physiographic types, but like the rest of Kentucky would show only mature dissection.

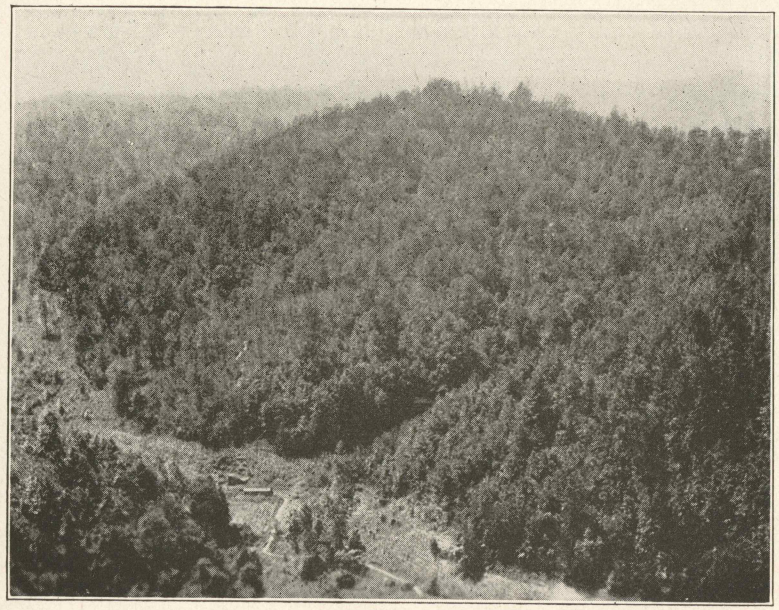
## Alluviation

*Regional Fill*: Western Kentucky well exemplifies the geological principle of regional alluviation. This filling is widely distributed, chiefly as fluvatile but in part as lacustrine deposits. As a physical feature it is best shown in the central interior of the Western Kentucky coal field on the Central City, Madisonville, Calhoun, and Sutherland quadrangles. On these quadrangles unconsolidated sediments attaining a depth of considerably over 100 feet may be readily noticed in the vicinity of Livermore and Calhoun. While this alluviation is confined to the Green River and Pond River valleys, regional dynamics,



uplift and depression are indicated as its causal factors. On the Louisville quadrangle regional fill is also well shown in the vicinity of Mill Creek and South Park.

*Valley Fill*: As might be anticipated in an area of mature dendritic drainage of ancient origin, broad fluviatile alluvial areas are common in Kentucky. This is particularly true in the Western Kentucky coal field, the most notably depessed area of the State. In this vicinity, the Whitesville, Tell City, Spring



MATURE TOPOGRAPHY

The steep narrow ridges of this part of Wolfe County, Kentucky, have forced mountain farmers to occupy the restricted meandering creek bottoms. This view is typical of all those areas along or east of the margin of the Cumberland Plateau where the strong erosion resisting conglomerate of the Lee Formation (Pennsylvanian) is not present.

Lick, Sebree, Providence, Nortonville, Newburg, Morganfield, Madisonville, Little Muddy, Henderson, Hartford, Earlington, Drakesboro, Central City, and Calhoun quadrangles all show varying degrees of stream deposits within well defined valleys. The Uniontown and Kosmosdale sheets each exhibit good and strikingly different types of river flood plain features. On the Henderson quadrangle a good example of "ridge and shale"

topography so similar to head ridges is well shown within the great meander.

In the district further west in Kentucky the Shawneetown, Smithland, Paducah and Mound City sheets well exemplify fluviatile deposists within a valley of definite outline. Progressing northwestward along the Ohio River, the Kosmosdale, Ironton, and Greenup sheets show the same type of physical feature, while in the southeastern mountain district of Kentucky, the Williamsburg and Middlesboro quadrangles exhibit a type of constricted valley alluviation which is quite different from either of the other types referenced. In the Cumberland valley immediately above the Williamsburg townsite valley alluviated areas of broad feature are marked in outline. Their occurrence here is specifically due to local anticlinal uplift of probable Recent date in part at least plunging across the Cumberland River transversely to the northeast. In the vicinity of the town of Middlesboro, valley filling of considerable extent is very notable. This feature of comparatively Recent origin, is due to the ponding of the waters of Yellow Creek by uplift of the Rocky Face fault block.

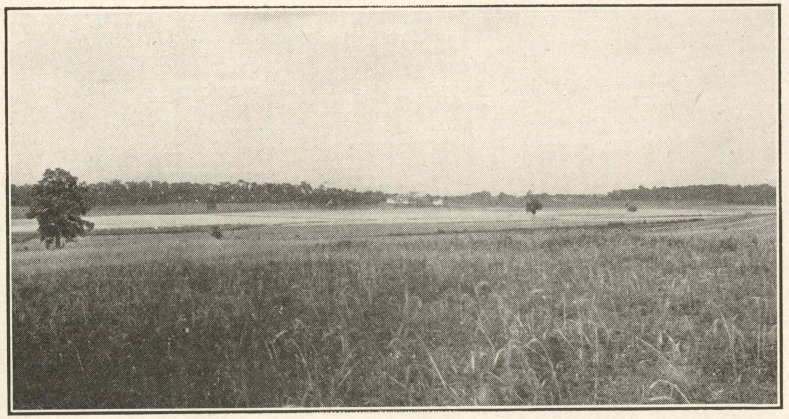
*Deltas*: In a region so perfectly drained as Kentucky, typical delta deposits are extremely rare. Lake and ocean shorelines being absent, one may expect to find the physical features accompanying delta formations only in areas of recent or present stream embarrassment. The valley of the Western Coal field affords two or three typical though small examples. The deltic features of these areas are to be seen principally on the Little Muddy and Brownsville sheets. The fact that the lower waters of tributary streams to the Green River are ponded back upon themselves forming small lakes and distributary deltic streams leading into the Green River may be taken as a certain proof of the fact that depression in the Western Coal Field is still in progress.

*River Terraces*: It is possible in almost every part of Kentucky to secure good examples of river terraces so broadly and intricately has the drainage pattern of the Commonwealth become. Most of the examples which may be cited will exhibit terraces of early, middle, and late Pleistocene age, but there are certain benches along the upper Green River, Middle and Upper Kentucky, the Upper Cumberland, and the medial waters of the



Big Sandy, Inez and Paintsville sheets, including levels of certain abandoned meanders which strongly suggest a more ancient origin, possibly Pliocene or somewhat earlier.

In Western Kentucky abandoned Pleistocene terraces on the Cumberland, Tennessee and Ohio are well shown on the Smithland, Paducah, and Mound City sheets, while the abandoned terraces of the Ohio are prominently displayed on the Newburg, Owensboro, and Prospect sheets. The Greenup and Kenova quadrangles in northeastern Kentucky exhibit high terraces of Pleistocene or pre-Pleistocene age at levels of about 680 feet.



BROAD UNDULATIONS NEAR HICKMAN
The topography of much of the country in the southwestern part of the Jackson Purchase is remarkable for these low gentle features.

These old benches may be ascribed to the central Teays River, a northward flowing pre-Pleistocene line of major drainage.

In the vicinity of Louisville on the Kosmosdale sheet a number of fine high level terrace remnants are shown in Floyd and Harrison Counties on the west side of the Ohio River at elevation of about 700 feet.

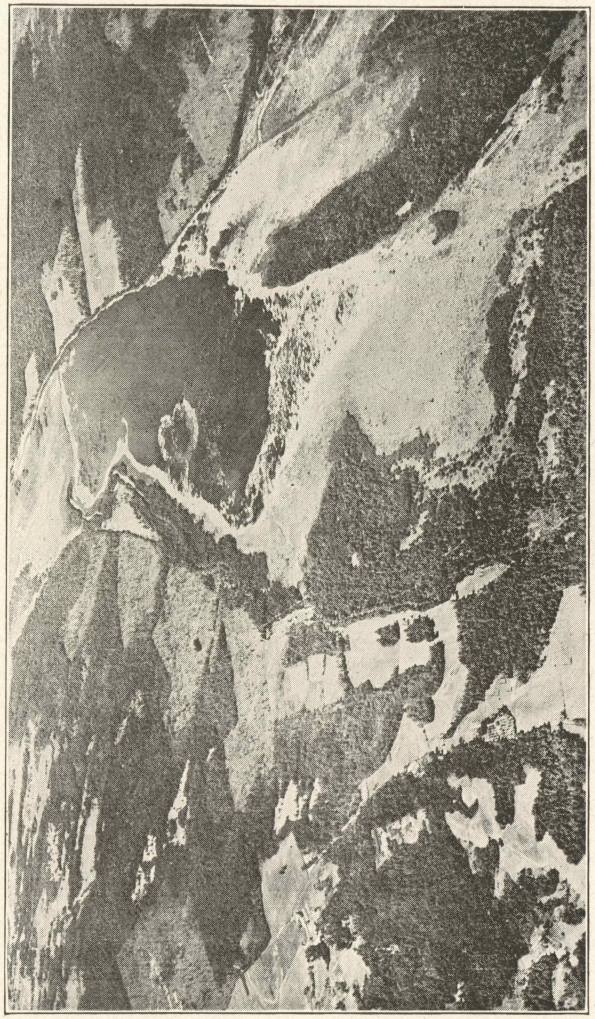
*Stream Lakes*: Kentucky, an area but slightly affected by glaciation can point to no lakes of Pleistocene age. Igneous activity either of ancient or recent times has been so slight in this State as to cause practically no embarrassment to the normal development of dendritic drainage systems. And furthermore regional uplift and depression have been developed in Kentucky on so broad a scale and through such a long period of

time as to have in but few instances caused embarrassment of drainage pattern, much less the development of true lake areas either in remote or recent geological times.

The Kentucky River, a notable exception to the above rule, meandering across the peneplained Cincinnati arch in the late Middle Tertiary, was appreciably embarrassed by Pliocene uplift aggregating about 900 or 1000 feet. Local faulting affected it but did not pond it. It remains anticedent. Evidence of this is to be seen along the Kentucky River fault in Clark, Madison, Fayette, Jessamine, Garrard, Mercer and Woodford Counties on the Richmond and Harrodsburg quadrangles. In Western Kentucky the depression of the southeastern tip of the central Interior coal field during the late Tertiary and Pleistocene fail to exceed the normal down cutting of the bed of the Ohio to any great degree, thus removing the possibility of a great lake in this Coal Measure area. In Eastern Kentucky the Paint Creek uplift in Johnson, Magoffin and Morgan Counties developing in the late Cretaceous or early Tertiary with a generally north and south axis was sufficiently rapid to divert the through flowing waters of the Big Sandy from the course now occupied by the Licking. The Levisa Fork shunted to the northeast found juncture with the Tug Fork at Louisa, but this movement did not permanently embarrass the west fork waters of the Big Sandy, nor is there any evidence that a lake was formed in this district even for a short time.

Leaving out of consideration, because of their ephemeral character, the many small sink hole ponds formed throughout the Karst region, Kentucky's natural lakes are few, small and all of stream origin. The Little Muddy, Brownsville and Mound City quadrangles exhibit the best examples of stream forming lakes which may be divided into three groups on a basis of their origin. Those shown on the lower waters of tributaries of the Green River and on the Little Muddy and Brownsville sheets are caused by regional depression and alluviation of the Green River valley. On the Mound City quadrangle the several lakes shown parallel to the Ohio are certainly old sloughs or abandoned channels slowly filling from flood plain sediments and organic deposits. Black Lake on the Central City sheet partly in McLean County and partly in Muhlenberg County, is an old



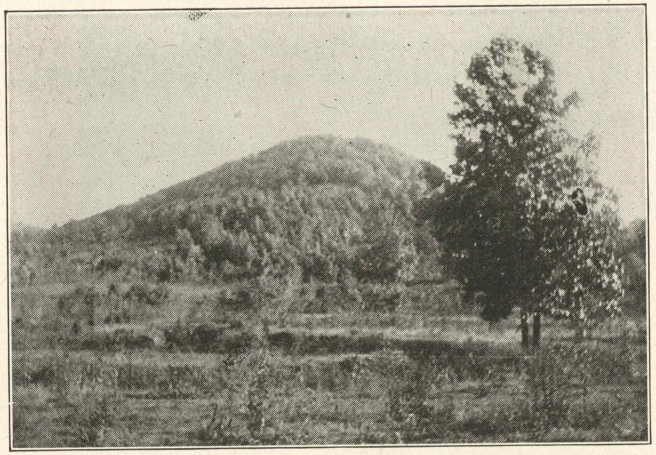


REELFOOT LAKE TOPOGRAPHY

This portion of the old Mississippi River flood plain exhibits only a very slight relief all of which is lost in a view from the air. Timbered hill lands on the east (left) rise from 150 to 200 feet above the lake waters, and form a southern extension of the Tertiary escarpment bordering the Mississippi River in Kentucky.

abandoned "ox-bow" of the Green River, and one of the finest illustrations of this feature in the interior of Kentucky.

*Earthquake Lake*: The best example of an earthquake lake in the United States is found on the Reelfoot Lake quadrangle, only a small portion of which tips into Kentucky. This area, subject to seismic influence from the earliest historical period, was severely shaken in what has come to be known as



TYPICAL KNOB-BELT HILL

Hundreds of such more or less isolated conical hills follow the crescent of the Devonian outcrop which surrounds the Bluegrass region. They are usually 250 to 350 feet high and are capped with somewhat resistant basal members of the Mississippian. Most generally forested, they present a striking and beautiful feature of the landscape.

the New Madrid disturbance of 1811-1812. At that time the region now encompassed by Reelfoot Lake was the flat alluviated drainage basin of Reelfoot Creek and Bayou du Chien, southwest flowing minor tributaries of the Mississippi River. Closely following the extended series of violent vibrations which have been rather fully described,[1] came depression of the region and the lake quickly took the form now indicated on this new quadrangle. This unique and shallow body of water has many areas particularly those tipping into Kentucky which are on the boundary line between true lake type areas and swamp areas. Alluviation is now rapidly going forward with the result that the area of this interesting lake is being steadily decreased.

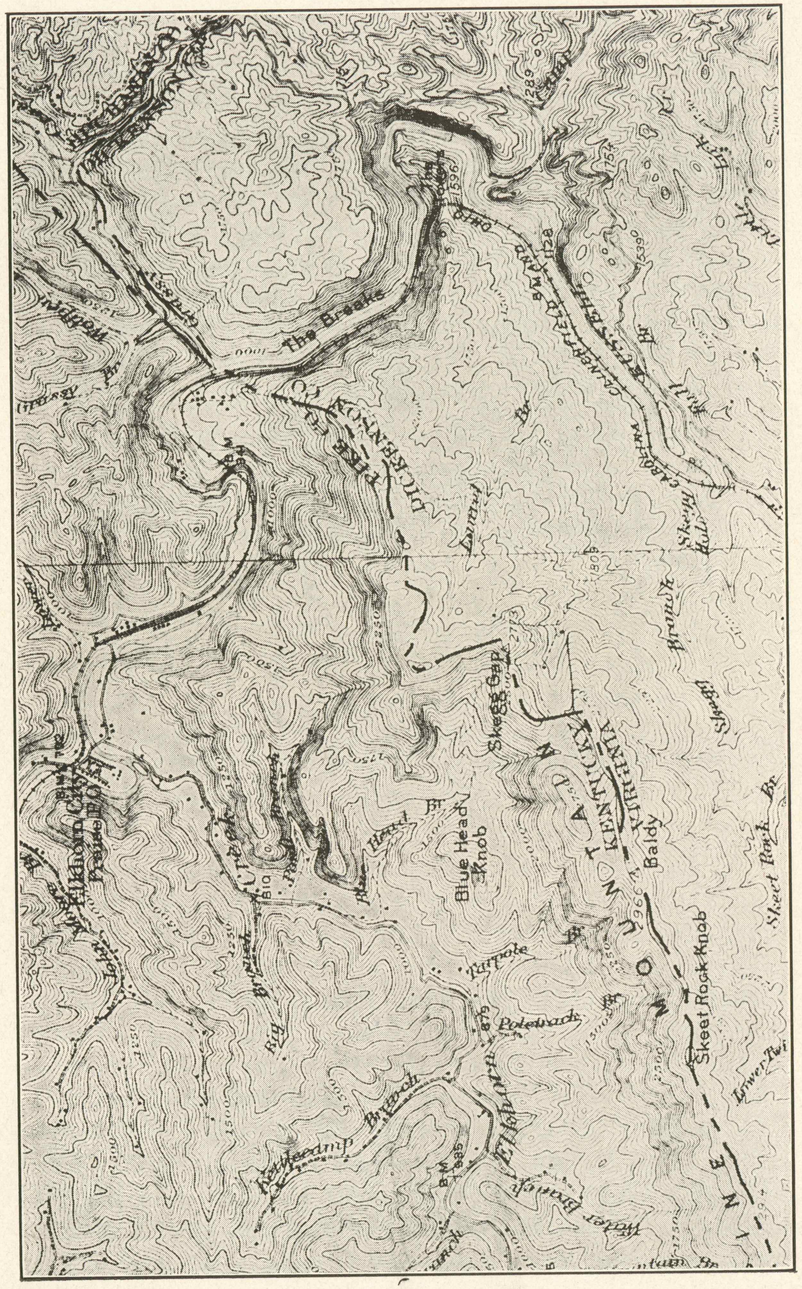
[1] New Madrid Earthquake, M. L. Fuller, U. S. G. S. Bull. 494, Washington, 1912.



*Variable Rock Hardness*: Many striking features of the landscape have their origin in the varying lithology of the earth's crust. On old sedimentary plains monadnocks in the form of low rounded hills or knobs capped by resistant layers often stand out as prominent landmarks. In areas of former igneous activity crumbling volcanic cones, dikes and sills frequently rise well above the normal relief and afford interesting physical features. In Kentucky broad regional dynamics coupled with a varying hardness of the sediments has resulted in many features belonging to the first class, while of the latter class the State possesses none unless reference be made to the Jeptha Knob, a cripto-volcanic structure in Shelby County.

In the Western Kentucky Coal Field along the line of strike of the Rough Creek disturbance, basal Coal Measure sediments, sandstones and sandstone conglomerates of the Caseyville formation somewhat metamorphosed locally, have been elevated much above their normal stratigraphic position. These sediments stand out as prominent physical features, particularly on the Morganfield and Sebree quadrangles. The Chalybeate ridge extending along a northwest-southeast line of strike a few miles south of Morganfield, is a feature of this character, while in the immediate vicinity of Sebree a range of hills including Bald Knob and extending eastward through Sebree Springs, Steamport Ferry and Congleton has had the same origin. For these features see the Sebree and Calhoun quadrangles.

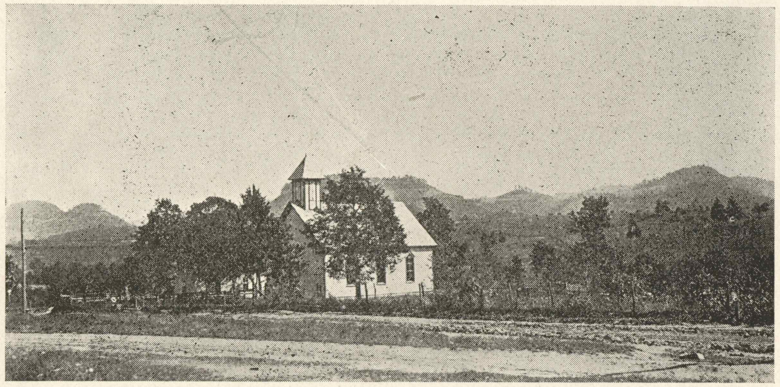
In Southeastern Kentucky, the Pine Mountain, a similar feature but of much greater figure, the largest in fact within this State, strikes north about 55 degrees east for many miles. It may be seen to advantage on the Cumberland Gap, Middlesboro, Harlan, Nolansburg. Clintwood, Pound, Regina and Whitesburg quadrangles. This great mountain range rising generally to elevations of about 2500 or 2800 feet is capped by the Pottsville (Pennsylvanian) conglomeratic sandstone which has been raised to elevations of at least 4,000 feet above its normal structural position by the Pine Mountain overthrust fault. This group of insoluble, slightly metamorphosed clastics in the Lee formation have successfully defied erosion and exhibit summit elevations ranging from 300 to 800 feet above the level of the Cumberland plateau to the northwest.




MATURE TOPOGRAPHY AND ANTECEDENT STREAM: "BREAKS OF SANDY."



Many monadnocks capped by the erosion resisting Pottsville conglomerate are common along the western margin of the eastern coal field throughout its extent from the northern part of Menifee County to the Tennessee line in Wayne County. These features are perhaps best shown on the Byrdstown and Monticello quadrangles. On the Byrdstown quadrangle Coppers Knob (1715 feet), Jennys Knob (1560 feet), Russell Ridge (1360 feet), Littoral Mountain (1695 feet) crossing the Kentucky-Tennessee line, and Golman Mountain (1825 feet) in Tennessee, are distinct and outstanding outliers of the Eastern



KNOBS TOPOGRAPHY NEAR PANOLA, KENTUCKY

Kentucky coal field. The superior hardness of the other ridge-top formations coupled with low solubility has produced in them and their adjacent hill lands isolated uplands ranging from 1400 to 1700 feet. The plain surrounding stands at an elevation of about 950 or 1000 feet. On the Monticello quadrangle Pilot Knob (1520 feet), Sulphur Spring Mountain (1540 feet), Ray Hill (1500 feet) and Crisell Mountain (1520 feet) rise about 500 or 600 feet above the Monticello limestone plain.

The northwestern tip of the Kentucky Knobs extends on to the southeastern quadrant of the Louisville sheet, and here South Park Hill, Nortons Hill, Shaddock Knob, and adjacent knobs and ridges capped with the rather insoluble Warsaw (Mississippian) limestones rise to elevations ranging from 750 to 840 feet; while the surrounding plain from Whitner through Okolona to Zonetown has been reduced to the level of

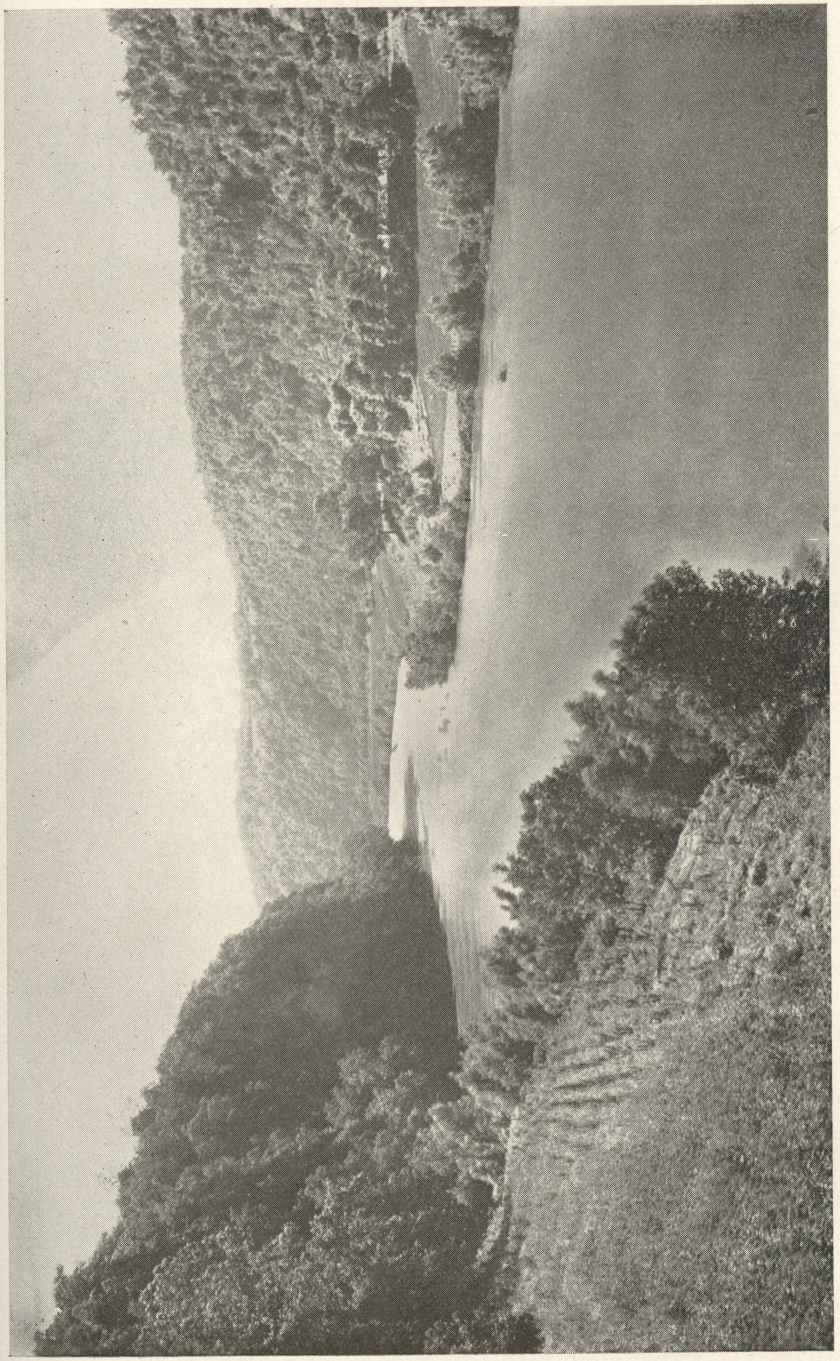
about 480 to 500 feet. The Knobs belt again is much in evidence in the southwestern quadrant of the Harrodsburg quadrangle where extending westward from Junction City through Parkville and Mitchellsburg one may see the pronounced Muldraugh's Hill, an escarpment comparable to the Highland rim of Tennessee. This range of hills rise to average elevations of 1300 feet, while the old Tertiary limestone plain upon which Danville and Perryville are located, exhibits elevations ranging from 850 to 1,000 feet.

In southern central Kentucky in the vicinity of Bowling Green there is exhibited another pronounced escarpment worthy of more consideration than geologists have given it. This scarp is upheld by a capping layer of the cypress (Chester-Mississippian) sandstone. It was described a few years ago[1] as a "Dripping Springs escarpment." A very pronounced physical feature, it extends from the vicinity of Barren River northward for many miles through Warren, Edmonson, Barren and Hart Counties. The Dripping Springs escarpment exhibits average elevations of about 700 feet, while the St. Louis (Mississippian) limestone upon which Bowling Green, Oakland, and Glasgow Junction are situated is about 200 to 250 feet below it. This important regional escarpment is shown on the Little Muddy, Brownsville, and Mammoth Cave sheets. All scale 1:62,500.

The Monticello sheet well potrays the very pronounced scarp which marks the western boundary of the Cumberland Plateau. It is rather unique in this connection since it is the only completed quadrangle in Kentucky that exhibits this feature at the scale 1:62,500.

*Erosion Cycles*: Excellent examples of two complete and a third incomplete erosion cycles are available for citation at many points in Kentucky. The Eastern Kentucky coal field exhibits in the accordance of summit elevations of its ridges what has been ascribed to be the Cretaceous peneplain.[2] Remnants of this late Mesozoic base level are now only to be seen in the narrow winding ridges with exception of an occasional upland plateau of very restricted area such as the "Flatwoods" shown on the southeastern quadrant on the Pikeville sheet just east of the main drainage of Shelby Creek. Here summit eleva-

[1] American Karst Country, Vol. XLII, Aug. 1924.
[2] London (Ky.) Folio, U. S. G. S., No. 47, Washington, 1898.



KENTUCKY RIVER GORGE TOPOGRAPHY

Pliocene Uplift and Subsequent Treching has produced in northern central Kentucky unique and scenic features of large and striking figure.

tions of 2,500 or 2,600 feet extend over a rather broad territory. These are only to be reasonably interpreted in the light of a remnant of this once far-reaching upland plain. Incised drainage levels range from 685 feet at Pikeville to 1017 feet at Dorton in the northeastern part of the quadrant two miles west of the Flatwoods district on Shelby Creek. Hellier with a drainage elevation of 1449 feet is but two miles northeast of the Flatwoods on the head of the Marrowbone Creek.

A very good contrast of the high western margin of the Cretaceous peneplain and the lower Tertiary peneplain is evidenced on the Richmond quadrangle. In the southern and southeastern part of this quadrant in the vicinity of Big Hill, Bear Mountain and Combs Mountain along the Madison, Estill, Jackson and Rockcastle County lines the western edge of the Cumberland plateau stands at elevations of about 1500 or 1600 feet. Somewhat to the northwest, the Tertiary base level sometimes referred to as the Lexington plain is cut down to elevations ranging from 950 feet to 1000 feet into the soft Ordivician limestones.

The Kentucky River and its major tributaries traversing this limestone area have entrenched themselves in meandering courses to drainage levels of about 550 feet, thus indicating for this section and other adjacent parts of Kentucky, for which this may be taken as the type, two complete cycles of erosion and definite progress in base leveling of the third. Inasmuch as the upland of central Kentucky has been ascribed to the Pliocene, the entrenchment of this limestone upland may be referred entirely to the Pleistocene and Recent period. For the presentation of similar topographical evidence of a complete cycle of erosion and the introduction of the third or present cycle, the reader is referred to the Harrodsburg sheet, while something of the same character of topography, though in a lesser degree, is shown on the northwestern quadrant of the Beattyville quadrangle in Powell, Clark, Montgomery and Menifee Counties. Additional examples of more than one erosional cycle may be seen on the Brownsville and Cub Run quadrangles. The same sort of feature may be noted on the Lockport sheet and to a similar degree and somewhat less apparent these features are present on the Frankfort and Harrodsburg quadrangles.

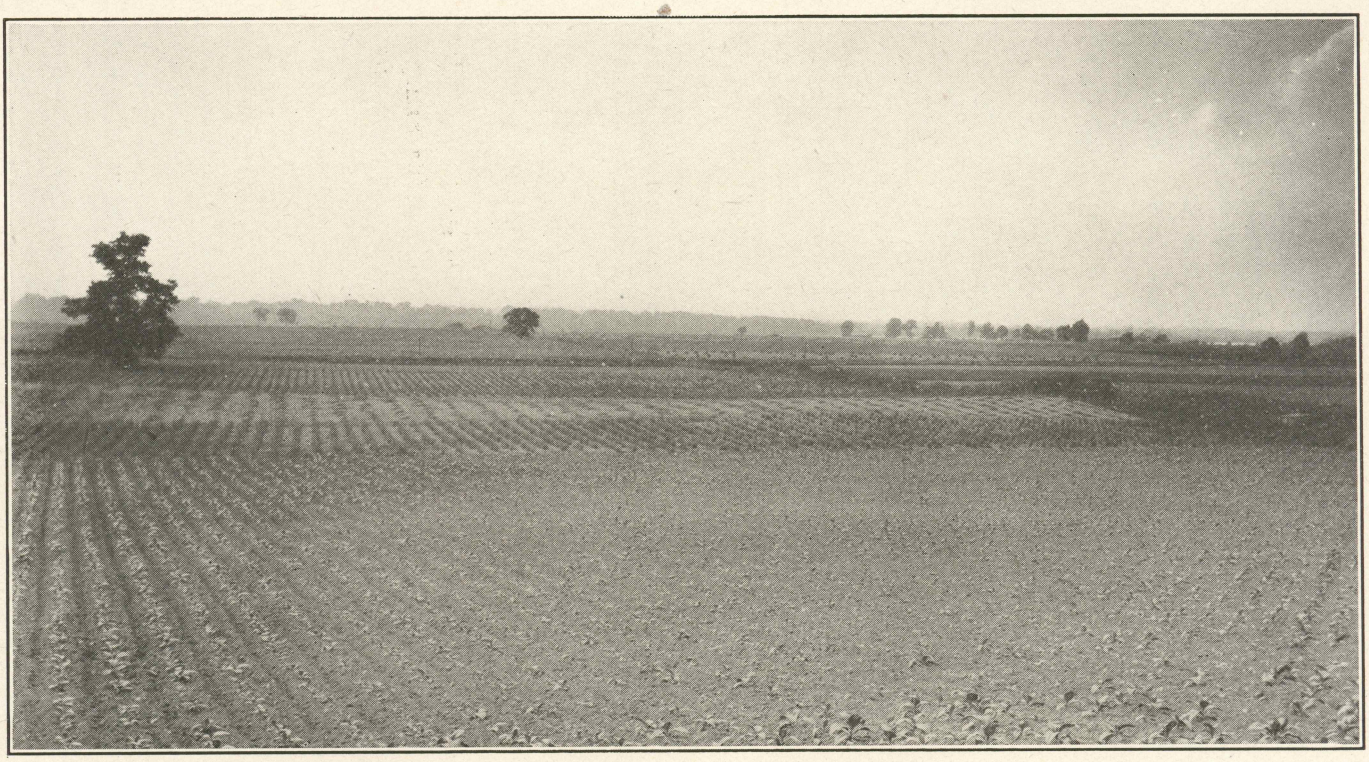


*Stream Piracy*: In a broad old land area such as Kentucky, one in which drainage patterns have been entrenching themselves uninterruptedly since the close of the Paleozoic, and for some included restricted regions such as the Bluegrass since the latter part of the Mississippian, it is apparent that many examples of stream adjustment might be cited. In fact the opportunity for the study of the modification of drainage involving the various forms of piracy is notably good in this commonwealth. Changes of drainage pattern due to structural influence are frequently met with in Eastern Kentucky, particularly in the areas of local structural deformation of unusually high angle. Other modifications due to the varying hardness and solubility of the sediments are notable in Central Kentucky in the Muldraugh's Hill or Knobs region where Ordovician and Silurian limestones come into contact with overlying siliceous and argillaceous Mississippian and Devonian beds of marked insolubility. In Western Kentucky and throughout the Mississippian limestone (Pennyroyal) plateau, and in the heart of the Bluegrass region where conditions of Karst topography are predominant, modifications of drainage pattern due to development of underground channels are of rather frequent occurrence.

Notable among the many modifications of drainage due to structure is that of Little Paint, Jenny's Creek, Burning Fork of Licking and Right Middle Creek, in Johnson, Floyd and Morgan Counties in Eastern Kentucky. These modifications are well shown on the Paintsville and Prestonsburg sheets. Larger features of modified drainage involve Paint Creek, Big Sandy and Licking Rivers. They have been described,[1] and are well seen by combining the Paintsville, Prestonsburg and Salyersville quadrangles.

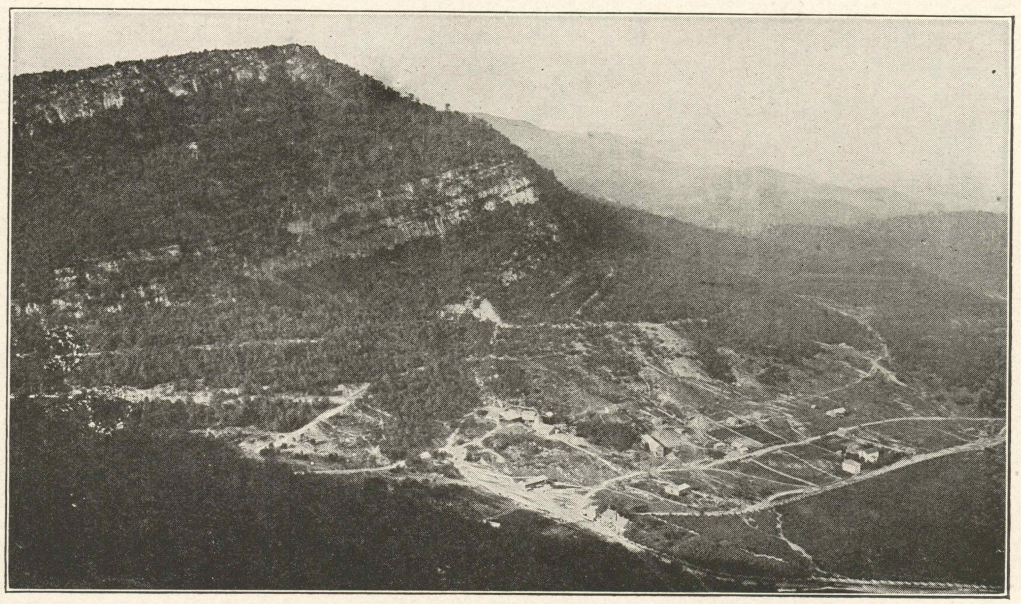
The Cumberland and the Pine Mountain somewhat parallel northeast and southweastward striking ridges in Southeastern Kentucky, exhibiting many wind gaps. Notable among them are the Pound, Ran Polly, Scuttlehole, Hurricane, and Cumberland Gaps. Most of these gaps, if not all of them, are to be identified

[1] Migration of the Headwaters Divide of Right Middle Creek, Floyd Co., Ky. Amer. Jour. Sc., Vol. XLVII, pp. 60-64, 1919, also Paint Creek Pirate, Ky. Geol. Surv., Series VI, Vol. II, 1921. Major Drainage Modifications of Big Sandy River, Pan. American Geologist, Vol. XLVI, Aug. 1926.



FEATURES OF OLD AGE IN LAND FORM

This view shows the great low and poorly drain flood plain bordering the Ohio River in the vicinity of Owensboro. Similar features follow this river to Henderson and Uniontown.



THE CUMBERLAND MOUNTAIN

Here in the vicinity of Cumberland Gap are shown the sharply tilted monoclinal sedimentary beds of the great Hunter valley anticline bordering Kentucky on the southeast. Ridge top beds are conglomeratic sandstone of the Lee (Pennsylvanian) formation, Mississpipian, Devonian, Silurian and Ordovician beds are exposed in sequence beneath on the Virginia side.

with obsolete drainage systems, most of which undoubtedly have not been effective since the late Cretaceous or early Tertiary.

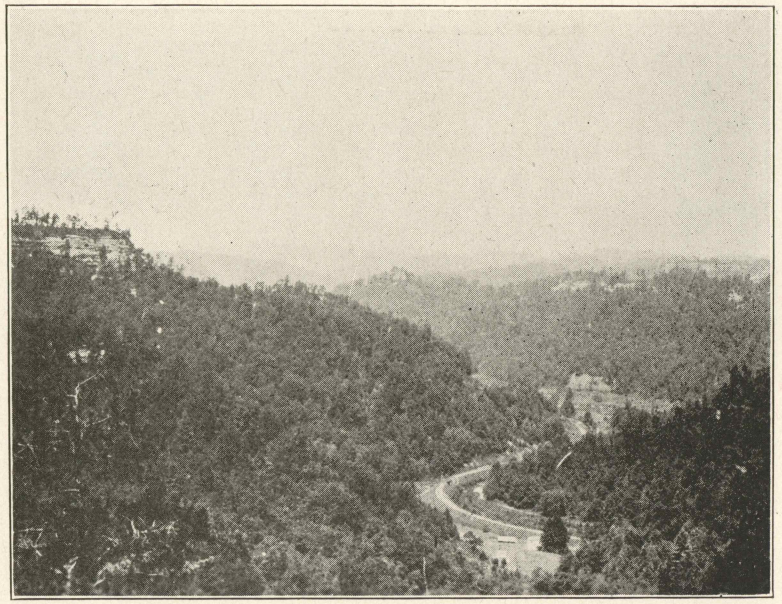
The Cumberland Gap with an elevation of 1649 feet, was evidently the course of a northwest flowing "through" stream heading in what is now the great "Smoky region" of Eastern Tennessee. The topographical features of this remarkable "wind gap" are well exhibited on the new Middlesboro quadrangle, scale 1:62,500. All of the southeastern headwaters of this ancient stream have been captured by the northeastern headwaters movement of the Powell and other upper tributaries of the Tennessee River. This great piracy was advantaged by high angle structure coupled with rocks of varying hardness and solubility. The Pound Gap with an elevation of 2407 feet shown on the Pound quadrangle marks an old drainage course of a through-flowing major headwater tributary, possibly of ether the Big Sandy or Kentucky River. Scuttlehole Gap in the Pine Mountain with an elevation of 2518 feet shown on the Whitesburg quadrangle is another abandoned water gap of a headwaters tributary to the North Fork of the Kentucky River. Hurricane Gap, with an elevation of 2263 feet, leading from the headwaters of North Fork of the Cumberland River at Chad to the Line Fork of the Kentucky River at Gordon is excellently shown on the Nolansburg quadrangle, as is Shell Gap with an elevation of 2605 feet dominating the rocky trail from Nolansburg on the Cumberland River to the Pine Settlement School on the head of Greasy Creek of the Middle Fork of the Kentucky River. Each of these gaps represents an abandoned drainage course of a former through-flowing northeast headwaters tributary of the Kentucky River.

In Central Kentucky drainage modifications of remarkable figure have been recognized for some time in the due north flowing waters of the North Fork of the Salt River in Mercer and Anderson counties. This drainage, so evidently in pattern a part of the Kentucky River, has been captured by the Salt River and diverted to the west. The old gap is well shown on the Harrodsburg quadrangle about a mile north of the Mercer line in Anderson County in the vicinity of McBrayer, and has been described in detail.[1]

[1] Pleistocene of Northern Kentucky, F. Leveritt, Ky. Geol. Survey, Series VI, Vol. XXXI, 1928.



In Western Kentucky one of the most notable examples of piracy due to the effects of underground waters is to be seen on the Cub Run quadrangle in the vicinity of Lone Oak Church. Here the headwaters of Dry Run, a rather considerable stream plunging into a sink hole by subterranean channels, have evidently been captured and diverted to Spike Laurel Run, a southward flowing branch of Nolin River.

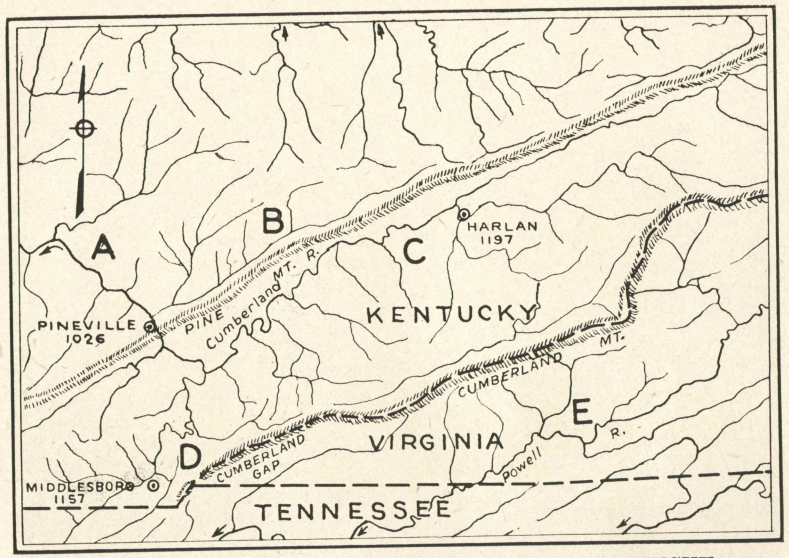


RIDGE CLIFFS AND ENTRENCHED MEANDERS

This type of topography on the head of the Red River near Torrent in Wolfe County is characteristic of the western border of the eastern coal field. The precipitous cliffs of Lee conglomerate (Pennsylvanian) are well distributed throughout this district.

*Stream Adjustment*: Many splendid instances of stream adjustment are to be seen in Kentucky, particularly in the southeastern part of this State adjacent to the high angle faulting and folding along the Pine and Cumberland Mountains. The North Fork of the Cumberland River may be cited as a stream which is consequent to the folding and faulting evidenced by the Pine and Cumberland Mountains. Throughout its course this stream is more or less parrallel to the Pine Mountain and through long distances flows immediately at the

foot of the southeast flank of this sharply defined mountain range. It is a truly synclinal stream throughout its course above Pineville. On the north or northwest side of the Pine Mountain, minor subsequent drainage of the Cumberland, Kentucky and Big Sandy Rivers is well shown in Mud and Poplar Lick Creeks, Clear Creek, Straight Creek, and Greasy Creek of Cumberland River, Laurel Fork of Greasy Creek, and the




STREAM ADJUSTMENT IN SOUTHEASTERN KENTUCKY

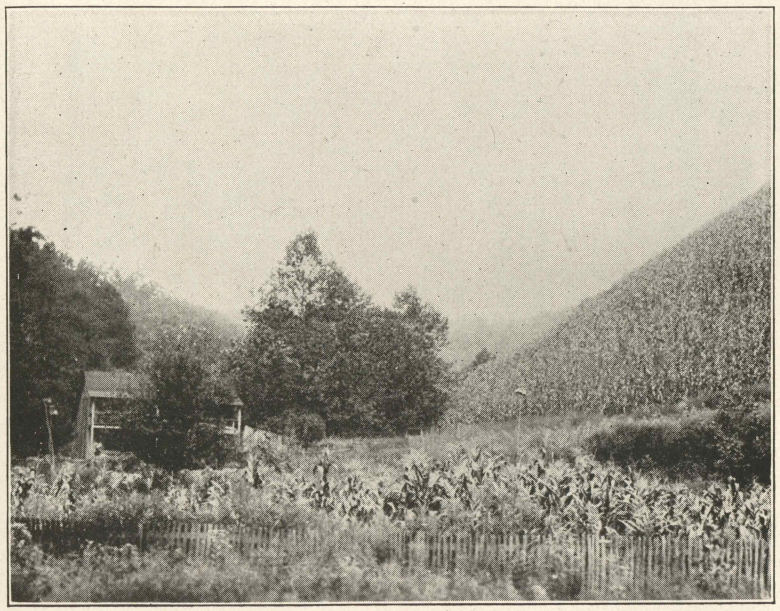
Cumberland River waters at A are antecedent at B subsequent, and at C consequent. Cumberland Gap is located at D. The consequent drainage of the Powell River is shown at E.

headwaters of Greasy Creek and Line Fork of the North Fork of the Kentucky River, the headwaters of the Kentucky River and Elkhorn Creek of Big Sandy River. This fine illustrative group of adjusted or subsequent streams may be seen by reference to the Cumberland Gap, Harlan, Nolansburg, Cornettsville, Big Stone Gap, Whitesburg, Pound, and Regina quadrangles.

The adjustment of drainage to comparatively low angle folding may be seen, as has been referenced under the heading of "piracy," on the Paintsville, Prestonsburg and Salyersville quadrangles. Minor adjustment due to faulting is much in evidence in the vicinity of Rocky Face Mountain on the Middlesboro quadrangle. Here the waters of Yellow Creek, a north-flowing tributary of the Cumberland River, have been deflected



southwardly by the Rocky Face fault and uplift, from what was evidently the original direct course. In Central Kentucky the course of the Kentucky River at a point a few miles north of Ford in Clark County has been sharply turned to the southwest evidently in consequence of uplift on the northwest side of the Kentucky River fault. This exceptionally fine illustration of the turning of a major stream in its middle course while traversing the top of the Cincinnati arch may be seen on the Rich-



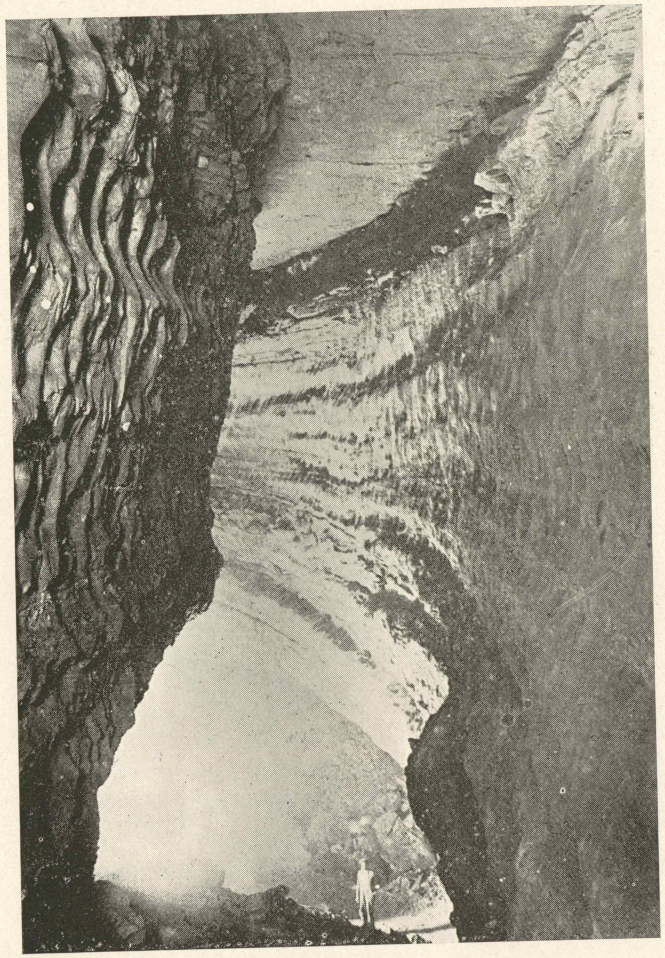
FLAT V-SHAPED VALLEYS

This type of mature topography is well developed in many parts of the Cumberland plateau where the upper part of the stratigraphic column does not exhibit strong and massive sandstones. A section composed predominantly of shale and thin sandstones produces low flat-angle hill lands and rather broad alluviated bottoms. This view is in northern Breathitt County.

mond and Harrodsburg quadrangles. After flowing southwestwardly many miles out of its course, the Kentucky again resumes its normal northwest trend about a mile below the mouth of Sugar Creek in northern Garrard County.

One of the most important citations of subsequent drainage in western Kentucky is that of Sugar Camp Creek which parallels the fault at the base of Newman's Bluff on the eastern side of a considerable graben of Pennsylvanian measures in western

Livingston County only a few miles east of the Ohio River. This notable piece of adjustment is not altogether uncommon as a type in the complexly faulted flourspar, lead and zinc field of Crittenden and Livingston Counties. It is well shown on the



A GIANT SUBTERRANEAN PASSAGE
This view shows what is known as "Grand Canyon Avenue" in the Great Crystal Cave. It is over 150 feet high.

Golconda quadrangle. On the Sebree quadrangle uplift along the Rough Creek fault passing through Sebree has resulted in diverting the waters of Dear Creek from their former channel

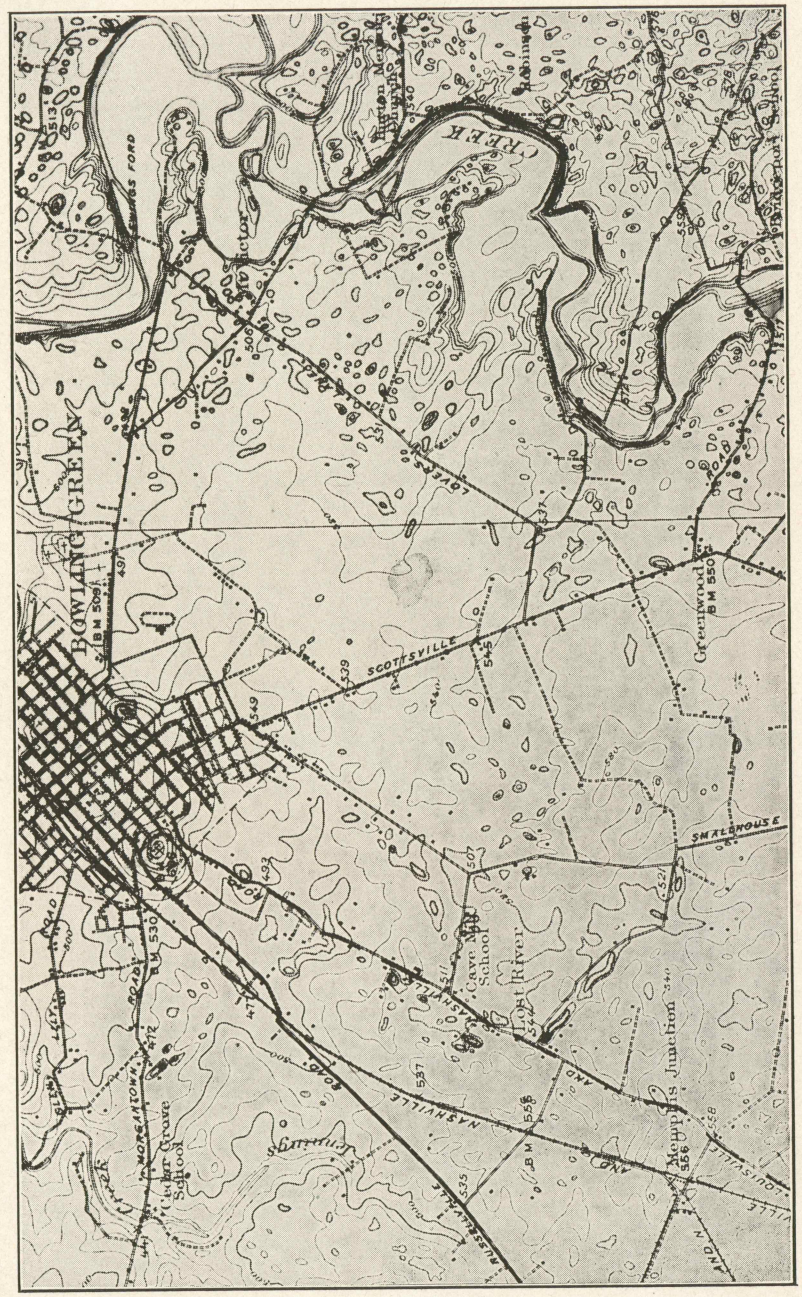


as indicated by the abandoned "wind gap" at Sebree Springs now used by the Louisville and Nashville Railroad. Following this structural advantage a small tributary of Green River reached back westwardly by headwaters erosion and captured probably late in the Pliocene, the main waters of Knoblick and Deer Creeks.

*Topographic Effects of Ground Water*: Kentucky affords the type locality of North America for a study of the modifying influences of subterranean drainage. A broad belt corresponding roughly to the outcrop of the St. Louis-Ste. Genevieve limestones (Mississippian) in western Kentucky exhibits to a greater or lesser degree the effects of ground water. The most important locality is of course in the vicinity of Mammoth Cave, but Karst topoghaphy is in evidence over a very wide area which has been described[1] as occurring in Livingston, Lyon, Caldwell, Trigg, Christian, Todd, Logan, Warren, Allen, Barren, Hart, Larue, Grayson, Hardin, Meade and Breckenridge Counties. While the number of sink holes in any given area in this region may vary with that of another area of similar size, it is not at all unusual for a single quadrangle to exhibit as many as 1000 drainage depressions. The Mammoth Cave quadrangle presents 2833 sink holes; the Brownsville 1150, and the Bowling Green 2563 holes; while a calculation of the number for the entire State has indicated about seventy or eighty-thousand. In some restricted districts subterranean drainage inlets are actually so numerous as to merge one into another without any level or surface within the area intervening. The largest sink hole of the State is at the foot of Dripping Springs escarpment between Tuckertown and Girkin, in Warren County. It shows an area of nearly five square miles. Excellent examples of the effects of underground water, sink holes, crumbling caverns, lost streams and basins of discontinuous surface drainage may be found well illustrated on the Leitchfield, Georgetown, Cub Run, Cave-in-Rock, Bowling Green, Scottsville, Big Clifty, Princeton, Mammoth Cave and Brownsville quadrangles.

*Entrenched Meandering Streams*: Unusually fine types of entrenched meandering streams are to be found almost everywhere in Kentucky. The deepest entrenchments occur of course

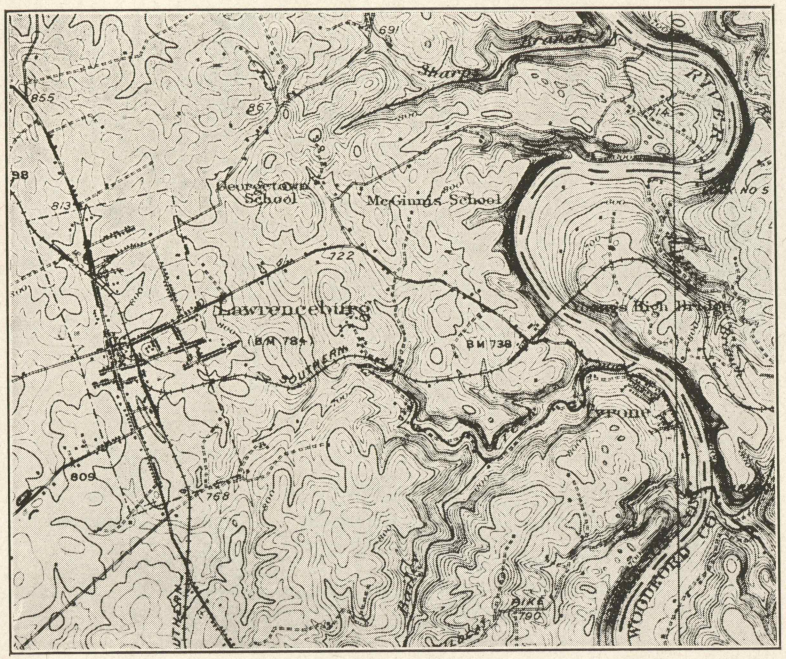
[1] American Karst Country. Pan. Amer. Geologist, Vol. XLII, Aug. 1924.




TOPOGRAPHY OF KARST AREA NEAR BOWLING GREEN



in the Cumberland plateau region the "Mountains" of Eastern Kentucky. In the southeastern part of this Commonwealth the meandering coursees of the rivers and their major tributaries are so pronounced as to be well worth critical study. Good examples of the meandering dendritic drainage of eastern Kentucky are to be seen on the Beattyville, Prestonsburg, Pound, Pikeville, Paintsville, Williamson, Williamsburg, Salyersville,




ENTRENCHED MEANDERS OF THE KENTUCKY RIVER

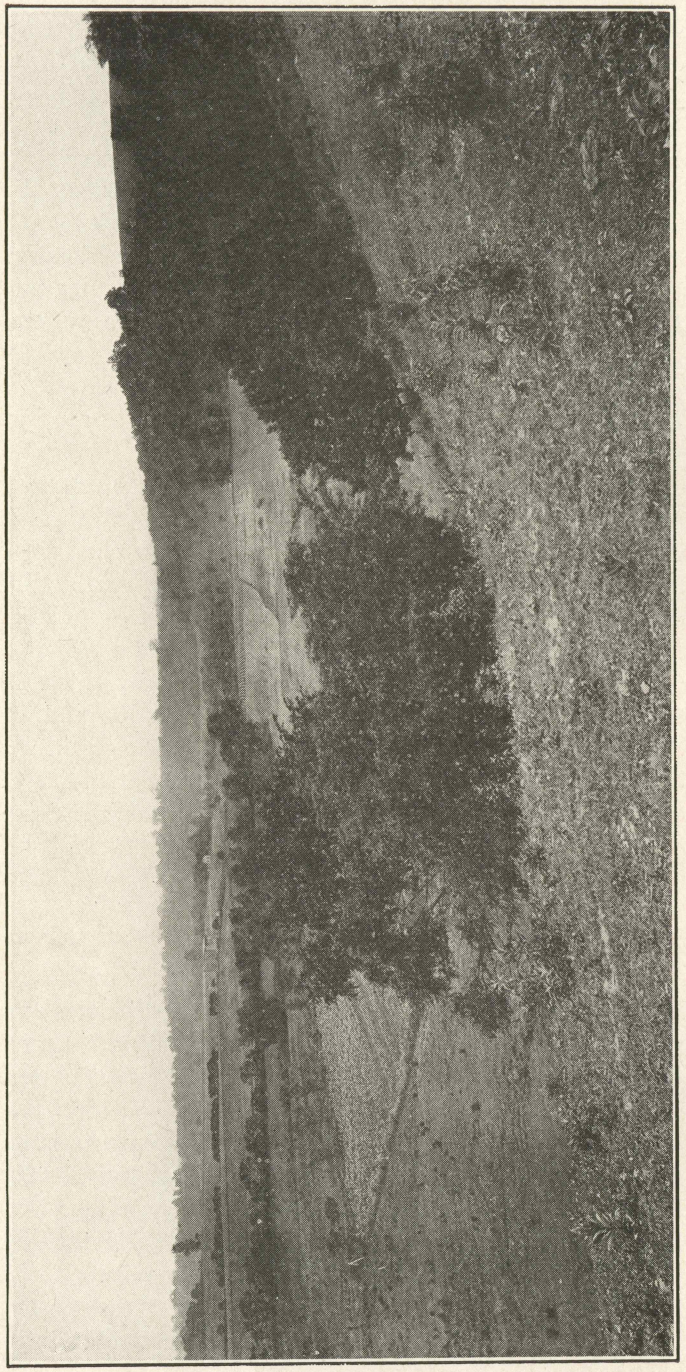
Regina, Troublesome and other adjacent quadrangles. It is probably true that the most unique entrenchments of meanders is to be found in the Bluegrass region of Kentucky where the Kentucky River has chiseled its course down through the Ordovician limestones 300 to 400 feet below the Lexington plain. Here are shown on the Richmond, Harrodsburg, Georgetown, Frankfort, and Lockport quadranglees the best gorged meanders and abandoned meanders of Kentucky. Good meandering entrenchment in the western Bluegrass, however, is also well shown on the Mt. Eden, Taylorsville, Louisville and Prospect quadrangles. On these south flowing waters of the Salt River, beauti-

fully entrenched meanders follow one after the other in rapid succession.

In southern and western Kentucky the lower Mississippian and Pennsylvanian plateaus are sharply etched by the meandering course of the Cumberland and Green Rivers. These are well shown on the Monticello, Byrdstown, Lilly Dale, Tompkinsville, Brownsville, Big Clifty, Cub Run, Little Buddy, Hartford, Dunmore, Princeton, Providence, Mammoth Cave, Leitchfield, Bowling Green quadrangles. In addition to the above the following quadrangles show entrenchments of meanders: Matewan, Naugatuck, Monticello, Middlesboro, Manchester, Louisville, London, Lockport, Kenova, Inez, Hyden, Hurley, Hindman, Harold, Greenup, Dawson Springs, Cumberland Gap, Cornettsville, Clintwood, Central City, Cave-in-Rock, Calhoun, and Buckhorn.

*Abandoned Meanders*: There are perhaps no better examples of abandoned meanders of entrenched streams than those which exist in central Kentucky. Most notable of this group of topographical features are those which are shown on the lower waters of main Elkhorn Creek in the vicinity of "The Backbone" and Bethel Church. The Kentucky River, beginning just below its gorge at the mouth of Glenn's Creek and continuing onward down stream to Gratz, exhibits a number of excellent old abandoned meanders. Those at Frankfort and Polsgrove are classic. These old meanders so readily seen in the field and so strikingly portrayed by modern topography, are well shown on the Georgetown, Frankfort and Lockport quadrangles, latter two being the type sheets for the state. An exceptionally fine abandoned meander is also shown on the new Taylorsville quadrangle at Taylorsville, and another of large proportions is seen at Burnside on the unpublished Burnside quadrangle.

In eastern Kentucky abandoned meanders are not of as recent release from the parent stream course as in the northern central part of the State, but there are nevertheless a number of them in the valleys of the Licking and Big Sandy Rivers. On the latter stream high old meanders abandoned possibly in the late Pliocene or early Pleistocene occur on the Inez and Paintsville quadrangles. In western Kentucky probably the largest abandoned meander entirely within the State of Ken-



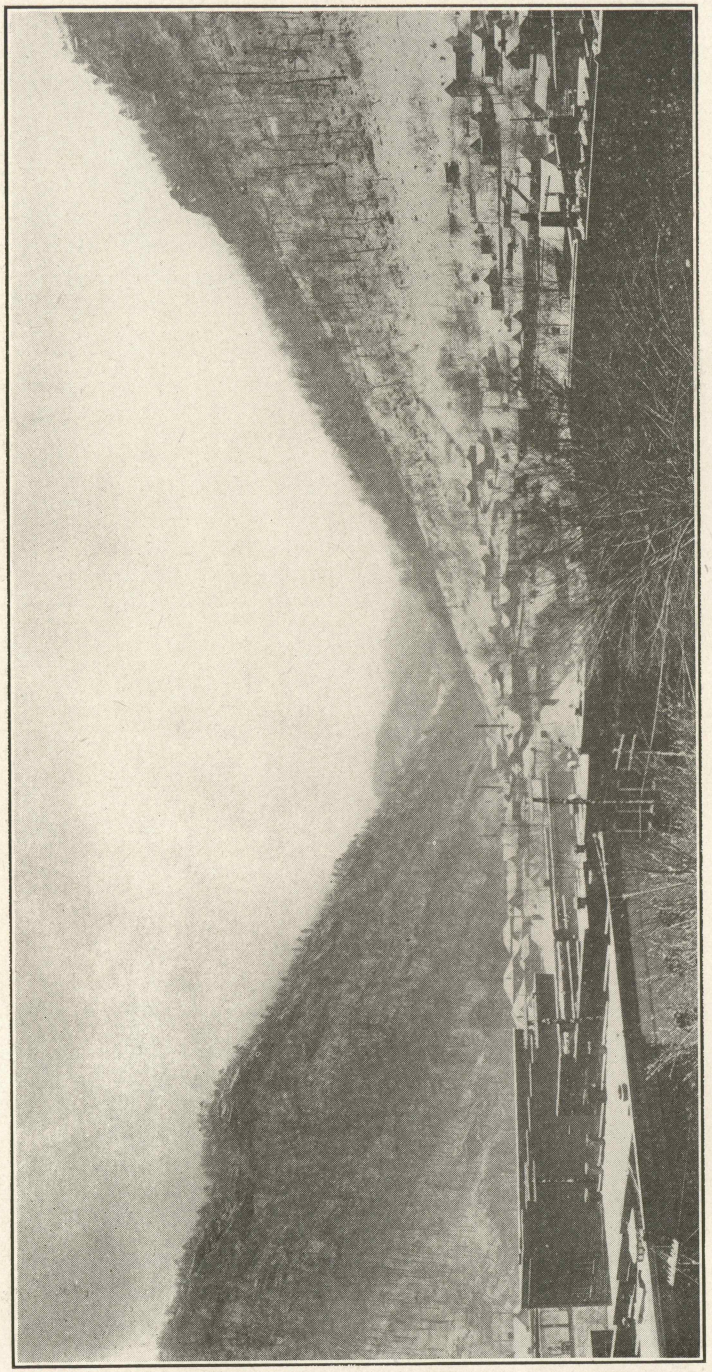
AN ABANDONED MEANDER IN ELKHORN CREEK, FRANKLIN COUNTY

tucky occurs slightly south of Livermore on the Central City quadrangle. Here the Green River turns with singular rapidity to the north and slipping into the very narrow former channel of Elk Creek cuts through a low range of hills in the vicinity of Point Pleasant, to be joined at Livermore by the Rough River. To the west the town of Island is situated on a low knob which was formerly surrounded by the Green River in its broad westward meandering course now abandoned. The old valley is now highly alluviated and imperfectly drained by the waters of Cypress Creek. Black Lake overlaping into McLean and Muhlenberg Counties is the abandoned oxbow of Green River.

*Glaciation*: Rather poor examples of glacial topography are presented by the terrian of Northern Kentucky. So small an area in this State was actually over-ridden by the Pleistocene ice sheet that one must look elsewhere for many characteristic glacial features. Drumlins, eskers, and kames, lake bed deposits horizontal and deltic are missing. There may be seen, however, on the Cincinnati double sheeet and on the unpublished Lawrenceburg, Rising Sun, Walton, Owenton, and Campbellsburg quadrangles the figure of outwash deposits, high level glacial stream beds and terraces. On the Louisville and Prospect sheets there is much evidence of Pleistocene filling, and in the western coal field, the Newburg, Calhoun, Central City, and Madisonville quadrangles exhibit as do others adjoining, the features of glacial ponding and aluviation. The diversion of the Green River on the Central City sheet may very reasonably be ascribed to the ponding induced in part by Pleistocene glaciation.

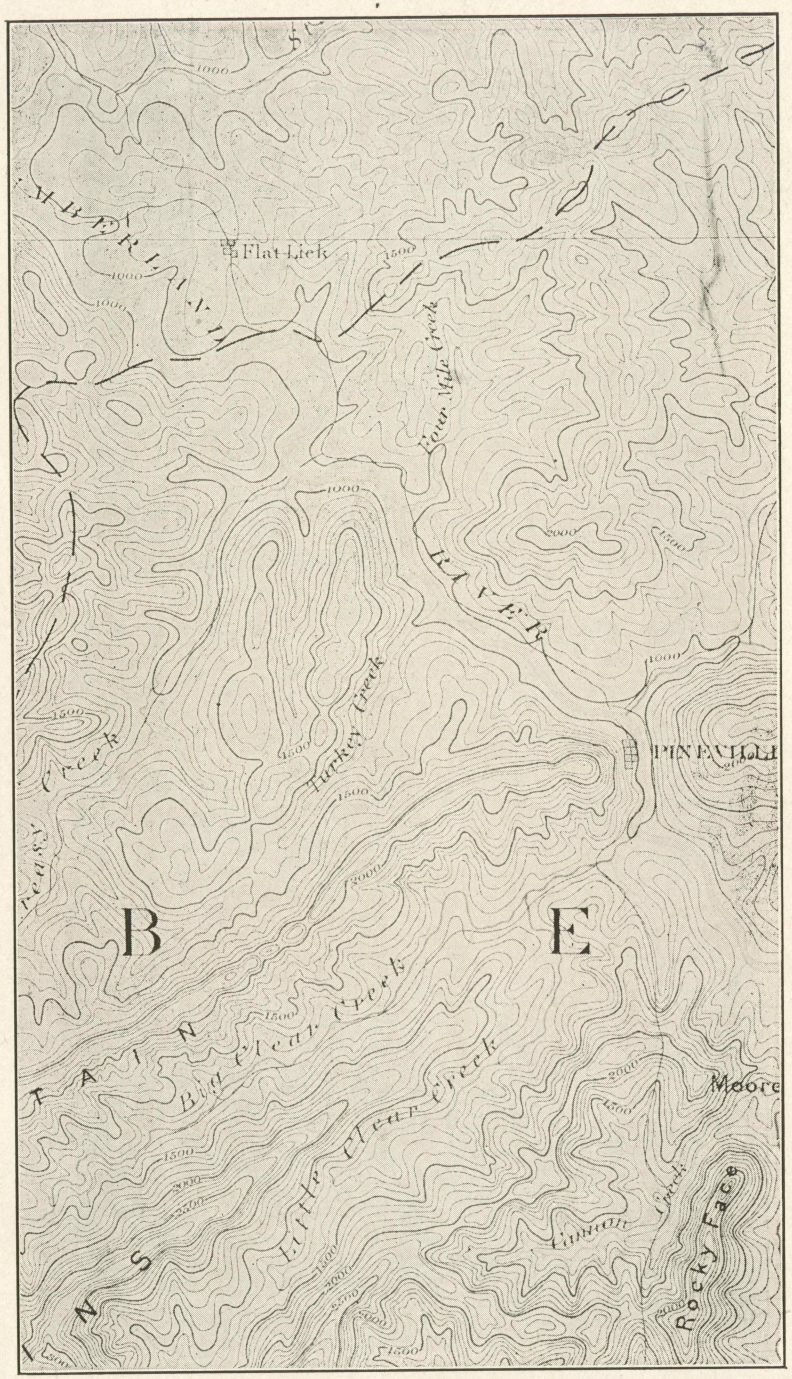
While it is now certain that large areas of Northern and Northeastern Kentucky were either glaciated or ponded during early Pleistocene times, large Canadian igneous and metamorphosed igneous erratics having been found in western Lewis, southwestern Rowan, and northern Breathitt, such topographic features as may have been produced at this time were apparently so lightly etched in the landscape as to have left little if any physical criteria.

*Lake Shores*: As has already been indicated, Kentucky is a maturely dissected old land surface. Having been so very slightly glaciated it presents no natural lake areas of consequence. Artificial lakes of recent construction and relatively



THE PINEVILLE GAP

At this point the Cumberland River an anticedent streams breaks through the great Pine Mountain. The topography shown here from Pineville is quite typical of this mountainous region. The view is upstream to the southeast.




TOPOGRAPHICAL EXPRESSION OF PINE MOUNTAIN FAULT

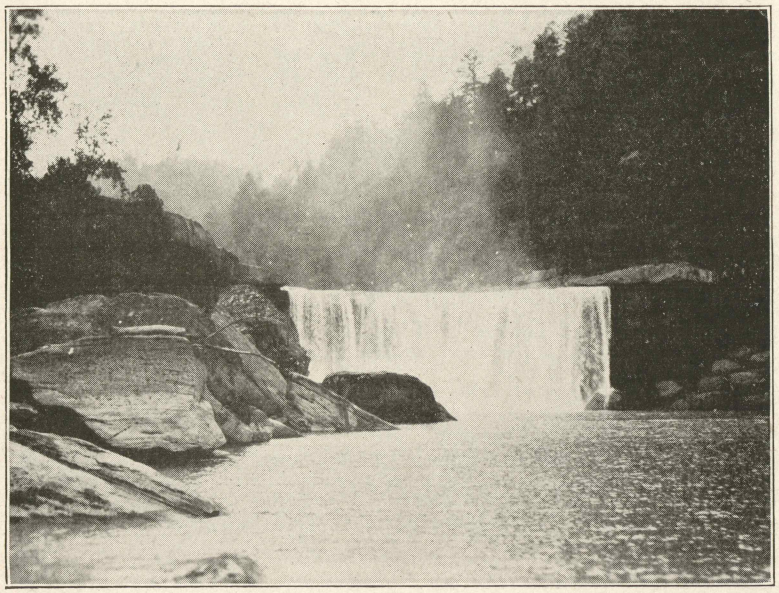


small area occur at a number of points, particularly at Jenkins below Pound Gap, South Park near Louisville, Kuttawa in western Kentucky, in the vicinity of Lexington, the Dicks River and elsewhere; but these lakes and reservoirs are of altogether too recent origin to have developed shore lines. Reelfoot Lake formed as a result of the great earthquake of 1811 is situated principally in Tennessee, but its northern tip extends somewhat into Kentucky. It is shown on the Reelfoot Lake quadrangle of Kentucky and Tennessee. The shore lines of this lake are low and indistinct being susceptible of broad areal change dependent upon low and high water conditions.

*Fault Lines*: Though located in that part of the central eastern division of the Mississippi valley characterized by low angle folding and slight normal faulting, Kentucky does present some rather exceptional topographic features brought about principally by normal and overthrust crustal breaks. The most striking feature of this character is the Pine Mountain of southeastern Kentucky. This great mountain range over a hundred miles long carries a rather uniform sky line ranging from 2500 to 3300 feet above sea level. It is narrow, clifted and high in local relief throughout. Recognized generally as the greatest overthrust fault in Kentucky, its displacement ranges from 2500 to 5000 feet. Though scarred by a number of "wind gaps" such as Pound, Scuttlehole, Hurricane and others, it is only crossed in this State by three major lines of antecedent drainage: (1) Russell Fork of Big Sandy at the "Breaks," (2) North Fork of the Cumberland River at Pineville, and (3) the Clear Fork at the Tennessee-Kentucky line. This pronounced topographical feature is well exhibited on the Cumberland Gap, Harlan, Nolansburg, Big Stone Gap, Whitesburg, Pound, Clintwood, Regina and Hurley quadrangles.

In western Kentucky the Rough Creek disturbance striking slightly south of east from the vicinity of Shawneetown is in part overthrust and in part normally faulted. Occasional high angle anticlines break the continuity of this line of disturbance. The faulted features are practically without exception characterized by pronounced hills standing generally about 250 or 300 feet above a rather featureless plain. These faulted hills usually exhibit on one flank or the other old clastic members of the basal

Coal Measures group. A rather pronuonced series of surface features, they extend eastward from the Ohio River to the Nolin River. They are exceptionally well shown on the Shawneetown and Morganfield quadrangles where they are known as the Chalybeate ridge. More or less prominent ridges indicate this disturbance on Sutherland quadrangle, but this feature is almost lost on the Whitesville sheet. On the Leitchfield and Cub Run quadrangles the line of disturbance is again percep-



A REMARKABLE HANGING VALLEY

In the vicinity of Cumberland Falls as shown here there are a number of well developed hanging valleys some etched at seventy-five and one hundred feet above low water in the river gorge below. The Cumberland Valley is V-shaped above the falls and U-shaped below, throughout the gorge proper.

tible. Here its course is marked by a low scarp standing in contrast against a rather pronounced plateau capped for the most part by the Golconda limestone. Elsewhere in Kentucky as on the Golconda and Cave-in-Rock quardangles faulted topographic features are also in evidence. On the first of these sheets, Newman's Bluff is an escarpment following the faulted eastern edge of a pronounced Coal Measure graben, while the complexly faulted features of the district lying west and southwest of



Marion in many instances are entirely in accordance with the axial lines of the hills and ridges over a wide area.

*Regional Uplift*: Physical features created by regional uplift are not likely to be preserved for long geological periods in areas of comparatively soft sediments. The greatest uplift in Kentucky, the Cincinnati Arch, is low in angle and very ancient in origin, though its last considerable upward movement, referenced to the Pliocene and possibly late Pleistocene, may be still somewhat in effect. Nevertheless this great structural feature is but barely shown by any single topographical sheet and only by piecing together a series of sheets such as the Kosmosdale, Louisville, Taylorsville, Mt. Eden, Frankfort, Georgetown, and Lexington quadrangles; or the Harrodsburg, Richmond, and Beattyville quadrangles is one able to see distinctly outlined the regional characteristics of this great uplift.

In southern Kentucky as has already been indicated the Pine Mountain uplift and fault is sharply outlined in feature both in the field and on any of the topographical sheets on which it is mapped, these being the Middlesboro, Cumberland Gap, Harlan, Nolansburg, Big Stone Gap, Whitesburg, Pound, Clintwood, Regina and Hurley. Cumberland Mountain the northwestern eroded flank of a great anticline further to the southeast is well shown on the Middlesboro, Sneedville, Hagan, Harlan, Nolansburg, and Big Stone Gap sheets, scale 1:62,500. The older reconnaissance topographical sheets, Cumberland Gap, Jonesville, and Estillville, also show this great range at the scale of 1.125,000.

In the north central part of the eastern coal field the Paint Creek uplift with a generally north and south axial line about forty or forty-five miles in length in Floyd, Magoffin, Johnson, Morgan, Lawrence, and Elliott Counties is but very poorly shown on the Kenova, Paintsville, Salyersville, Prestonsburg and Hindman quadrangles. This feature, however, is for the most part of characteristically low angle. It certainly dates back to the late Cretaceous if not to more ancient geological periods. In the soft easily eroded shales, sandstones, and coals forming the Middle and Upper part of the Pottsville in this region, weathering has proceeded with evident rapidity throughout the Tertiary and Pleistocene periods. As a result few outstanding phy-

sical features are left to be identified with this pronounced uplift. Somewhat further to the west in Laurel County, the Rockcastle River uplift extending northeastward from Farriston on the Louisville and Nashville Railroad across Clay and Owsley counties to the Breathitt County line is of fairly high angle along its axial crest. As a result the line of strike of this structure is followed by a series of hills and ridges prominently shown on the London and Manchester sheets. These are known as Frazier Knob, Laurel Hill, Raccoon Mountain, High Knob, Pilot Mountain, Cradlebow Knob, Rice Knob and Rose Knob. In western Kentucky as has already been indicated, the regional uplift accompanying the Rough Creek disturbance is well shown on the Morganfield, Sebree, and Calhoun quadrangles.

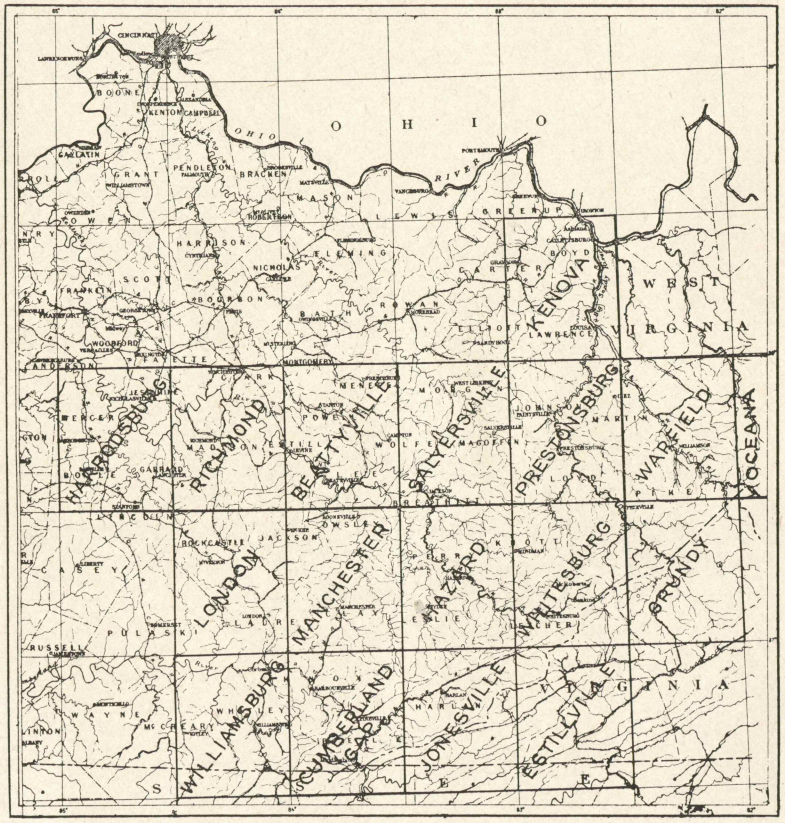
### Geographic Distribution of Quadrangles

The distribution of the topographical surveys in Kentucky is interesting as a key to the location and development of mineral resources of the State. The earliest topographical work was done in Eastern Kentucky by Sidney S. Lyon and assistants for the First Geological Survey of Kentucky under the direction of the then State Geologist, Dr. David Dale Owen. These surveys were made in Greenup, Carter and Lawrence counties in 1857. The scale was two and one-half inches equals five miles. Use was made of black line contours to express the land forms but no attempt was made to give these contours exact or semi-exact elevations and thus present the topography in its true relationship. Contouring at this early time was little more than reconnaissance sketching and only a step advanced from the representation, of relief by hachures. At the time this work was done the very important and active Hanging Rock iron ore and pig iron producing region was centered in Greenup County which then included a part of what is now Boyd.

In 1882 the United States Geological Survey began its large scale topographical work in Kentucky with the Jonesville, Cumberland Gap and Estillville sheets. Others adjoining soon followed until in all seventeen sheets and part sheets at the scale of 1:125,000 were completed for the Eastern Kentucky coal field The last sheet to be completed at that scale was the Kenova quadrangle, which also bears the distinction of being the best of the

KARST AND HILL LAND TOPOGRAPHY
There is shown here a quadrant from the central western portion of the London sheet the published scale of which is 1:125,000. This drawing has been enlarged slightly more than 100 per cent. The Sinking Creek valley shown here is mostly in Pulaski County and is cut into the Mississippian limestone. East of the boundary line the Laurel County area is practically all in the Lee formation (Pennsylvanian). The contour interval is 100 feet. The region shown is on the western border of the Cumberland plateau.

older reconnaissance surveys. It has now long been recognized that this old topography is both too inaccurate and too insufficient in detail to be of much aid in modern field investigations. For this reason no more work of this scale, 1:125,000, will be done in Kentucky. Many of these old sheets have already been replaced with new topography, scaled 1:62,500. The earlier




INDEX TO RECONNAISSANCE TOPOGRAPHY IN KENTUCKY

scale is still being used with some degree of success in the broad western mountains and plains country where more refined investigations are not now necessary and may not be for many years.

The complete list of the old reconnaissance topographical



sheets, all of which were surveyed in Central and Eastern Kentucky, follows. The date of the field work is given.

| | |
|---|---|
| Beattyville | 1890 |
| Cumberland Gap | 1882-1886 |
| Estillville | 1882-1883 |
| Grundy | 1883-1884 |
| Hazard | 1889 |
| Harrodsburg | 1902-1903 |
| Jonesville | 1882-1885 |
| Kenova | 1900-1901 |
| London | 1891 |
| Manchester | 1887-1888 |
| Oceania | 1883-1884 |
| Prestonsburg | 1884-1885 |
| Richmond | 1890 |
| Salyersville | 1889-1897 |
| Warfield | 1883-1885 |
| Whitesburg | 1883-1885 |
| Williamsburg | 1886-1887 |

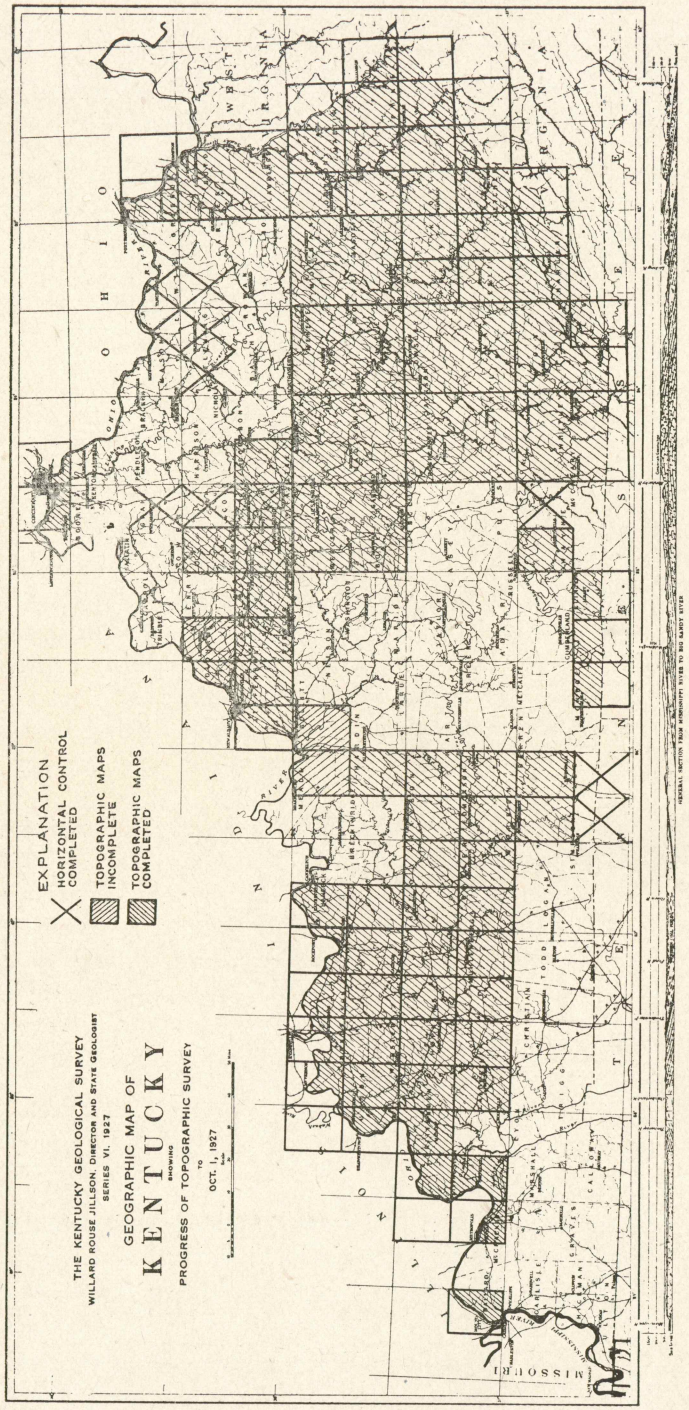
Within more recent years an intermittent continuation of the topographical work in Kentucky has resulted in the completion of ninety full and part sheets, all of the new work being done at the scale of 1:62,500 with contouring at twenty or fifty feet as the type of local relief seems to indicate most advisable for its most accurate and detailed delineation. These sheets given regional geographical distribution, some covering parts of two physical regions, are as follows:

*The "Mountains:"* Greenup, Kenova, Beattyville, Salyersville, Paintsville, Inez, Naugatuck, Prestonsburg, Harold, Williamson, Matewan, Gilbert, London, Manchester, Buckhorn, Troublesome, Hindman, Pikeville, Regina, Hurley, Hyden, Cornettsville, Whitesburg, Pound, Clintwood, Williamsburg, Cumberland Gap, Harlan, Nolansburg, Big Stone Gap, Middlesboro, Sneedville, and Hagan.

*The "Knobs:"* Prospect, Kosmosdale, Louisville, Harrodsburg, Richmond, and Beattyville.

*The "Bluegrass:"* Prospect, Louisville, LaGrange, Taylorsville, Mt. Eden, Lockport, Frankfort, Harrodsburg, Georgetown, Lexington and Richmond.

*Mississippian Plateau:* Golconda, Cave-in-Rock, Smithland, Princeton, Dawson Springs, Nortonville, Drakesboro, Dunmore, Little Muddy, Brownsville, Bowling Green, Scottsville, Mammoth Cave, Cub Run, Leitchfield, Big Clifty, Spring Lick, Tompkinsville, Lillydale, Byrdstown, Monticello, London, Beat-




INDEX TO TOPOGRAPHY IN KENTUCKY



tyville, and the large scale military special sheet of Camp Knox and region surrounding in Hardin County, Ky.

*Western Coal Field*: New Haven, Uniontown, Henderson, Newburg, Owensboro, Tell City, Shawneetown, Morganfield, Sebree, Calhoun, Sutherland, Whitesville, Providence, Earlington, Madisonville, Central City, Hartford, Spring Lick, Leitchfield, Cub Run, Princeton, Dawson Springs, Nortonville, Drakesboro, Dunmore, Little Muddy, Brownsville, and Mammoth Cave.

*Jackson's Purchase*: Mound City, Paducah, Smithland, and Reelfoot Lake.

THE MISSISSIPPIAN PLATEAU

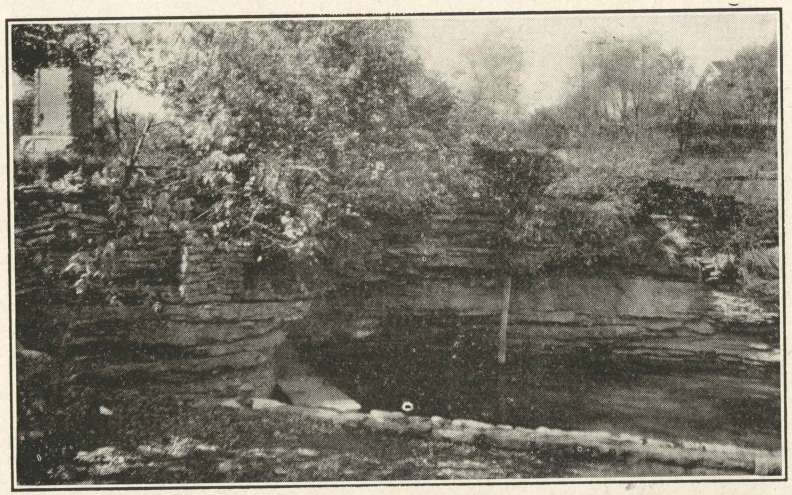
Much of the northern part of this great natural subdivision of Kentucky is only slightly undulating and broad of feature. This view was taken near Flaherty in Hardin County.

## Recent Topographic Surveys

Within the last decade the need of detailed topographic maps for all parts of Kentucky has become more and more acute. Their value is particularly great in the construction of new highways. The road engineer at the present time is the largest single user of detailed maps. This great and specialized need for them is based upon the rapid expansion of the new high type road and highway system. The engineer must have them for location of State and County lines; he must have them for the measurement of the areas of drainage basins; he must have them to calculate

in advance the probable gradient; he should have them so as to select the type of road best adapted to the physical aspect of the countryside. For many other similar and equally important purposes, the up-to-date road engineer requests modern topographic base maps.

Not long ago inquiry was frequently made as to what constituted a topogrophic map. Now as this type of map finds a wider use than formerly—due to professional and industrial



THE "BIG SPRING"

Many portions of the Bluegrass and Pennyroyal plateau are marked by large springs of this type. This one in Ordovician limestone was the site of McClelland's Fort in 1774-5 at Georgetown, Kentucky.

demand for exact information—the question is put much less often. In brief a modern topographical map is simply a very accurately surveyed base map showing all and every kind of culture such as dwellings, schools, churches, towns, cities, county and State lines, roads, railroads, tunnels, canals, ditches, streams, rivers, falls, ponds, lakes, ocean shore lines, sink holes, hollows, branches, canyons, gorges, swamps, bottom lands, uplands, hills, valleys, mountains and much other information, including of course the "bench marks" giving the precise elevation of any certain point above sea level. This last named characteristic, however, the elevations as they are commonly called, is the greatest point of difference between the topographic map and any flat black and white map. The elevations give the map its principal



value. In order that the elevations of all points may be rather accurately shown a system of contouring is used. Brown lines are used, these being more or less parallel or in conformity of curve, and overlain on the regular base. These contours connect all points of equal elevation and coupled with the bench marks picture exactly the physiography.

Inquiry by the Kentucky State Highway Commission in 1925 as to the progress of topographic mapping in Kentucky revealed the startling fact that scarcely more than one-half of this State was topographically base mapped. To be exact, on July 1, 1925, of the 40,598 square miles in this Commonwealth, 20,723 square miles were base mapped topographically, whereas 19,875 square miles were without any topographical maps whatsoever. In general it may be said that the areas mapped in Kentucky fall into three groups, as a glance at the accompanying index chart will show. These are: I. The Western Kentucky Coal, Fluorspar and Asphalt fields; II. the Eastern Kentucky Coal and Oil fields, and III. a few scattered sheets throughout the Blue Grass, principally between Lexington and Louisville.

All of the Jackson Purchase was unmapped at the beginning of 1926, as was the central heart of Kentucky, radiating sixty miles in practically all directions from Campbellsville in Taylor County as a central interior point. Northern Kentucky from Olive Hill to Lexington was unmapped, as was the region between Lexington and almost to Cincinnati. Added to this it was found that Kentucky was not preparing any new or additional topographic sheets, because of a lack of direct appropriations for this purpose.

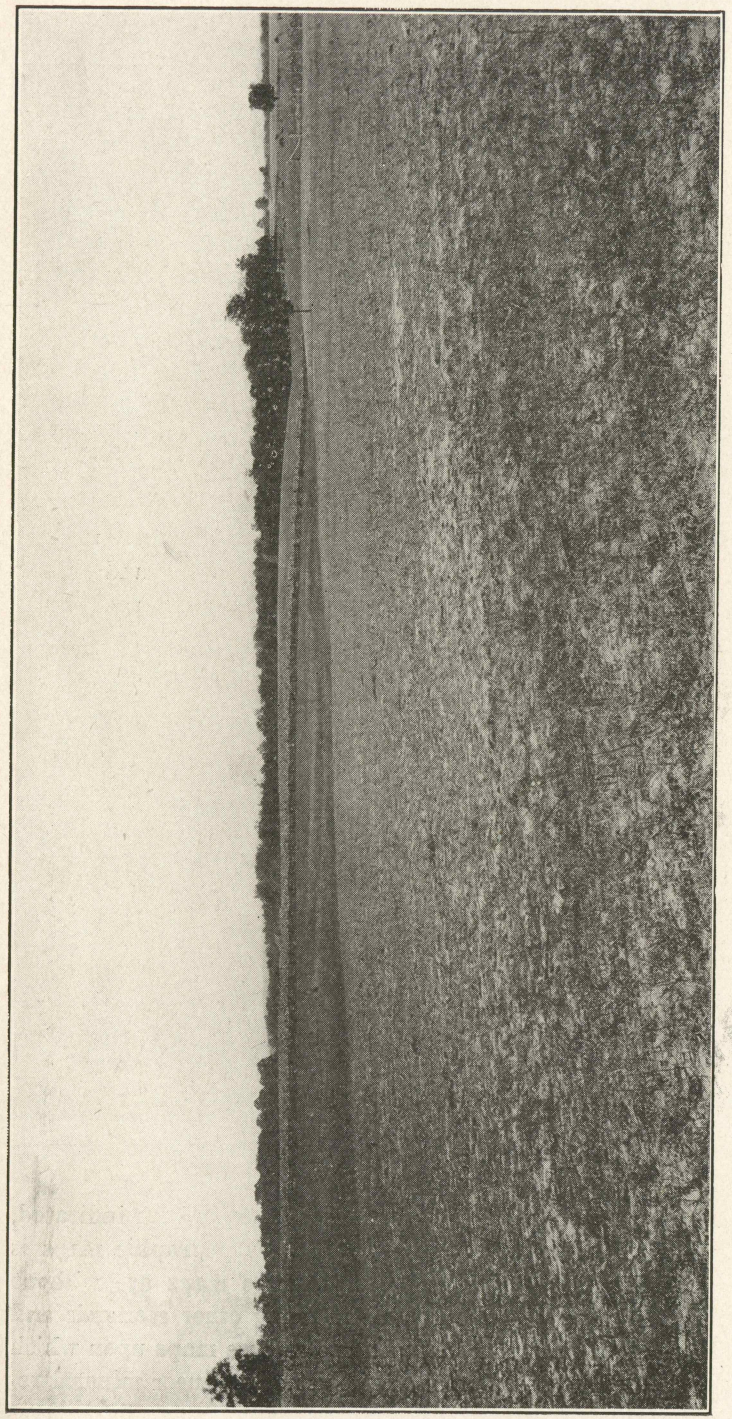
At this point in the investigation the Kentucky Geological Survey offered to proceed with any reasonable program of topographic mapping that the State Highway Department might authorize and finance. Advantage was taken of an enabling act in the Budget of 1926 and, the Highway Commission voting unanimously, appropriated $50,000.00, which the Director of the Kentucky Geological Survey accepted and matched with new funds in the same amount secured from the U. S. Geological Survey, Topographic Branch, at Washington. The Kentucky Highway Commission then suggested certain areas in which new and immediate mapping would preceed and decrease the cost of

the construction of new high type roads. The Director of the Kentucky Geological Survey approved these selections with some revisions and additions. The new work, scaled 1:62,500, or approximately 1 inch equals 1 mile, was spotted in for various separated areas from the waters of the Mississippi to those of the Ohio near the mouth of Big Sandy, and the headwaters of the Cumberland. In this way a State-wide distribution of the new topographical surveys was secured.

The program thus outlined, involving the largest piece of topographic base mapping ever undertaken in Kentucky, was quickly initiated. The work began on July 1, 1926, and in October reached its maximum with about forty engineers and assistants employed in the field. By the use of the most heroic methods during the entire season, indescribably bad because wet, a far flung and very difficult program was carried through to successful completion. The spirit of co-operation extended by the U. S. Geological Survey was of the first order and the field work which had been most energetically supervised by R. L. Harrison, was closed down about December 17, 1926.

In the short space of about five months fourteen new topographic sheets and part sheets had been surveyed. In addition two incomplete full sheets, the Scottsville and the Mt Eden, were finished and published, making a total completion of sixteen new fifteen-minute quadrangles. The new maps are known as the Mound City, Paducah, Smithland, Big Clifty, Tompkinsville, Lilydale, Byrdstown, Middlesboro, Hagan, Sneedville, Taylorsville, LaGrange, Big Stone Gap, and Greenup topographical sheets or quadrangles. Parts of the following counties were mapped: Ballard, McCracken, Marshall, Livingston, Lyon, Hardin, Breckinridge, Grayson, Monroe, Cumberland, Clinton, Wayne, Bell, Harlan, Anderson, Spencer, Shelby, Henry, Trimble, and Greenup.

Photographic and photolithographic preliminary editions of many of these new maps, such as the Mt. Eden and Big Stone Gap sheets, field work on which was started July 1, 1926, were delivered by the Kentucky Geological Survey to the State Highway Commission in November and December, 1926. The others were also quickly produced and all were placed in the files of the State Department of Roads and Highways early in the spring of

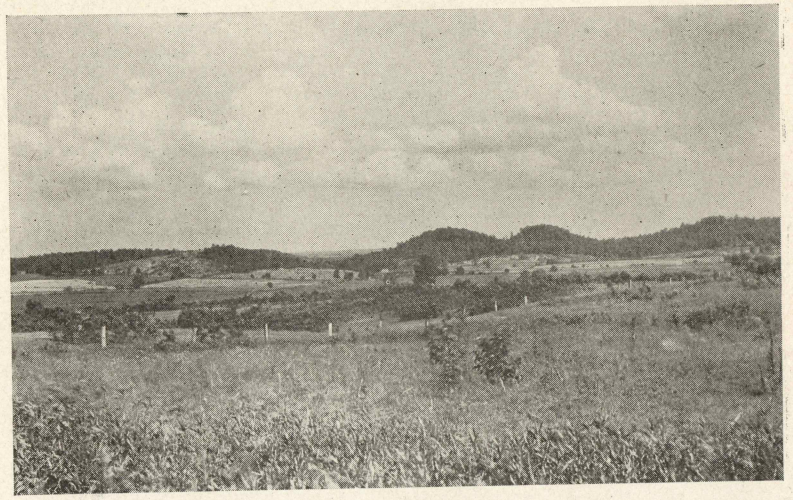


THE GOLCONDA PLATEAU

In the vicinity of Big Clifty in Grayson and parts of Hardin Counties. A pronounced upland of slight feature internally has been developed on the Golconda limestone (Chester-Mississippian). Big Clifty Creek trenches this plain.

1927. Utilizing control and level lines run in Fayette and Bourbon counties in 1926, field work in this area was continued in 1927, with the result that the Lexington quadrangle, joining the Georgetown sheet, has been completed and will soon be issued in preliminary photographic edition. All of the new topographical sheets, as well as the older ones, are now serving useful purposes in Kentucky highway engineering.

An instance of the practicality and economic value of good topographic maps is found in the case of the new Frankfort sheet, which was surveyed in 1924. The utilization of this topographic map in the location of the new Alton to Frankfort highway resulted in an estimated saving of upwards of a mile of new construction and between $20,000.00 and $35,000.00 in cost. Besides this the new route secured a more or less level upland course as contrasted to the former narrow, winding and rather steep route located alongside the waters of Cedar Run.



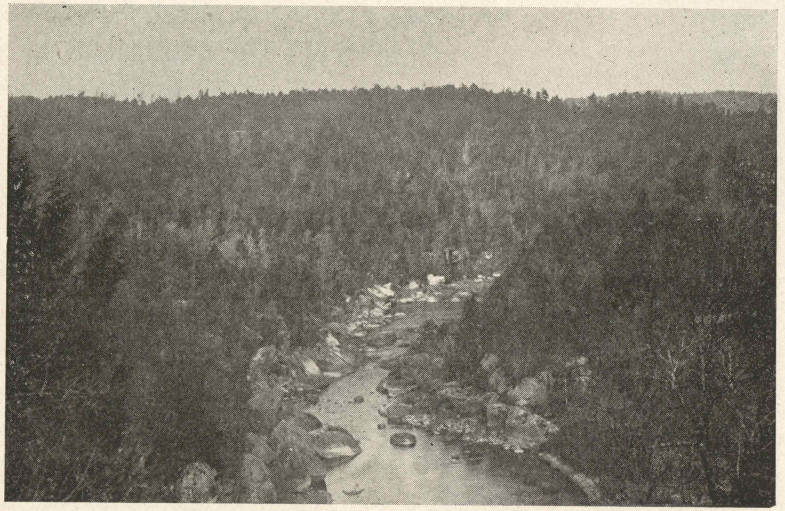
VARIABLE ROCK HARDNESS EXPRESSED IN TOPOGRAPHY NEAR PRINCETON, CALDWELL COUNTY.

Although at the present time, as has already been indicated, the greatest good arising from the use of topographic maps is in new modern highway construction, these maps are without question of the very greatest value in many other economic and social activities. They are of much use as base maps upon which may be located by a competent geologist or engineer mineral re-



sources of the State such as coal, petroleum and natural gas, building stones, clays, non-metallic minerals, metalliferous minerals and the various ores. These maps are excellent for any classification of public lands or mineral lands, for soil surveys and forest investigations. They are practically indispensable for the accurate determination of water resources and all broad problems of conservation and agriculture.

Topographic maps serve excellently as a base for military maps in the development of the National defense, for maneuvers of the Army and National Guard. These modern maps serve in



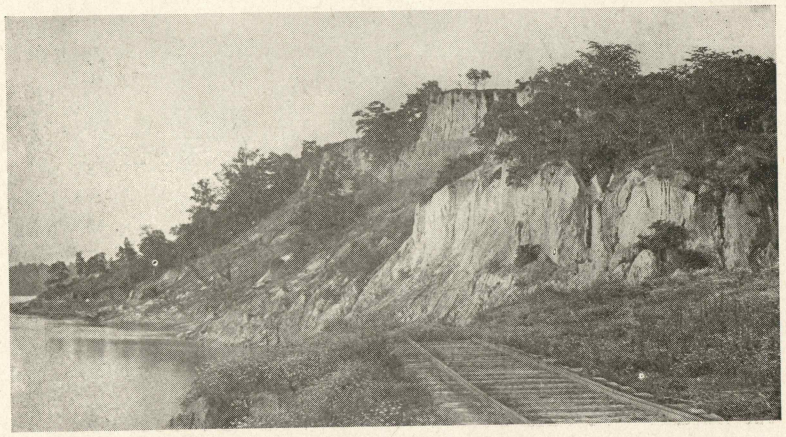
LOWER GORGE OF CUMBERLAND RIVER
This part of the stream below the falls has been proposed as a power project. A modern topographical map would aid in developing the region.

general engineering and in railroad as well as highway location, water power projects, irrigation, drainage, reservoir, power sites and canal construction. They afford bench marks and accurate points of triangulation for large scale detail surveys of rivers and harbors. Municipal administrations of cities make use of them in water supply work, flood control, sewage disposal, as well as for the determination of city limits, county boundaries, state lines and in the subdivision of land.

Aviation is making a constantly increasing use of topographical maps in the allocation of new aerial routes, landing fields, and in securing detailed accurate data at distant points in

the preparation of instructions for special flights. Not the least value attached to good topographic maps is that of general education for which they form an excellent foundation in teaching geography, physiography, and many other associated scientific studies. Travelers both at home and abroad find the topographic map is the best guide to new territory.

Under the present program Kentucky is rapidly forging to the front in the execution of her topographic base mapping. The work is executed in the field and published in quadrangular units known as "fifteen minute" sheets. In this latitude they are about 13.5 miles on an east and west line and 17.20 miles on a north and south line. The new Kentucky sheets are all scaled



UNMAPPED EMBAYMENT TOPOGRAPHY
These Tertiary bluffs near Hickman are part of a large area which should be mapped for flood control and highway work.

1:62,500 or about an inch to the mile. Contour intervals are 20 or 50 feet depending upon regional relief. A complete sheet in Kentucky covers about 242 square miles. Each sheet has a separate and generally unduplicated name. There are surveyed and available ninety sheets and part sheets in Kentucky at the present time.

While the cost of executing in the field and office this new and detailed base map differs from sheet to sheet due to the variation in land sculpturing from place to place, the amount and congestion of culture, the extent of forests and brush land, and the distribution of good and easily traveled roads, calculations



carried out over a period of several years indicate an average expenditure of about $35.00 or $40.00 per square mile. Reduced to a more easily understood standard this is equivalent to about five or six cents an acre. Such a reasonable basis of cost not only places these maps well within the purchasing power of Kentucky but makes it quite uneconomic to do without them. At the present time it is enough, perhaps, to point out that if the topographical program in effect during 1926 is not interrupted this State will probably be completely mapped topographically by 1933.

## BIBLIOGRAPHY OF KENTUCKY TOPOGRAPHY

Ashley, Geo. H., and Glenn, L. C.
Geology and Mineral Resources of Part of the Cumberland Gap Coal Field, Kentucky U. S. G. S. Professional Paper No. 49, Washington, 1906.

Birdseye, C. H.
Mapping the Country a $50,000,000 Task. The New York Times, p. 6, XX, Sunday, July 5, 1925.
Topographic Mapping and its Relation to Revival of Western Mining. The Mining Congress Journal, pp. 857-59. Illustrated. Washington, Dec., 1926.
Board of Surveys and Maps (U. S.). Trans. First Pub. Meet, Tuesday, March 9, 1920, Washington, D. C.

Butts, Charles
Geology and Mineral Resources of Jefferson Co., Ky. Ky. Geol. Survey, Series IV, Vol. III, Part II, 1915.

Campbell, Marius R.
Description of the Estillville Sheet, U. S. G. S. Folio No. 12, Topographic and Geologic Maps, Washington, 1894.
Description of the Richmond Quadrangle, U. S. G. S. Folio No. 46, Topographic and Geologic Map, Washington, 1898.
Description of the London Quadrangle, U. S. G. S. Folio No. 47, Topographic and Geologic Map, Washington, 1898.

Dake, C. L., and Brown, J. S.
Interpretation of Topographic and Geologic Maps. McGraw-Hill Book Co., New York, 1925.

Davis, William Morris
Topographic Maps of the United States. Scientific Monthly, pp. 557-560, Vol. XV, No. 6, Dec., 1922.

Frye, H. M.
Topographic Instructions of the United States Geological Survey (A. Administration), Bull. 788A, Washington, 1926.

Glenn, L. C.
Underground Waters of Tennessee and Kentucky West of Tennessee River and of an Adjacent Area in Illinois. U. S. G. S. Water Supply Paper No. 164, Washington, 1906.

Glenn, L. C.
Geology and Coals of Webster County, Ky., Geological Survey, Series VI, Vol. V, 1922.

Jillson, W. R.
Contributions to Kentucky Geology. Dept. of Geology and Forestry of Kentucky, Series V, Bull. IV. Contains "The Migration of the Headwaters Divide of Right Middle Creek, Floyd Co., Ky.," pp. 65-69, 1920.
Economic Papers on Kentucky Geology. Ky. Geol. Survey, Series VI, Vol. II, 1921.



The Sixth Geological Survey: An Administrative Report (Years 1920 and 1921). Ky. Geol. Survey, Series VI, Vol. VI, pp. 10-13, with topographic index map, 1921.
Administrative Report for the (Sixth) Kentucky Geological Survey (Years 1922 and 1923). Ky. Geol. Survey, Series VI. First printed as pamphlet in 1923, reprinted in Vol. XII, pp. 362-390. List of quadrangles and topographic index map, 1926.
Administrative Report for the (Sixth) Kentucky Geological Survey (Years 1924 and 1925). Ky. Geol. Survey, Series VI, Pamphlet V, pp. 22-24, 35-38. List of quadrangles and topographic index map, 1925.
Topographic Base Mapping in Kentucky. Ky. Geological Survey, Series VI, Vol. 12, Paper XI, Frankfort, 1926.

Lee. Wallace
Geology of the Kentucky Part of the Shawneetown Quadrangle. Ky. Geol. Survey, Series IV, Vol. IV, Part II, 1916.

Lesley, Joseph, Jr.
Topographical and Geological Report of the Eastern Coal Field of the State of Kentucky. Kentucky Geological Survey, Series I, Vol. IV, pp. 439-494. 1861.

Lyon, Sidney, S.
Topographical Report of that Portion of Kentucky including Union and part of Crittenden Counties, etc., Ky. Geol. Survey, Series I, Vol. I, pp. 381-400. 1856.
Topographical Report of the Geological Survey, through Hopkins, Crittenden, Caldwell, Greenup and Carter County, etc., Ky. Geological Survey, Series I, Vol. II, pp. 300-376. 1857.

Leighton, M. M.
Topographical Geological Report of the Progress of the Survey of Kentucky in the Counties of Greenup, Carter, Lawrence and Hancock for the year 1857. Ky. Geol. Survey, Series I, Vol. III, pp. 425-463. 1857.
Topographical Geological Report of the Progress of the Survey of Kentucky, etc. Ky. Geol. Survey, Series I, Vol. IV, pp. pp. 494-599. 1861.

Leighton, M. M. (Secy.)
Minutes of the Washington, D. C., Meeting, Association of American State Geologists, April 25-26, 1927.

Miller, A. M.
Geology of Kentucky. Dept. of Geology and Forestry of Kentucky, Series V, Bulletin II, 1919.
Geology of Franklin County, Ky. Ky. Geol. Survey, Series IV, Vol. II, Part III, pp. 1-87, 1914.

Phalen, W. C.
Description of the Kenova Quadrangle, U. S. G. S. Folio No. 184, topographic and geologic map, Washington, 1912.

Salisbury, R. D., and Atwood, W. A.
The interpretation of Topographic Maps. U. S. Geol. Survey, Professional Paper 60, Washington, 1908.

Schenk, C.
Topographical Report of a Part of Greenup and Lawrence Counties for the year 1874. Ky. Geol. Survey, Series II, Vol. V, Part II, pp. 11-22. 1880.

Sharp, Henry S.
Karst Topography and Cavern Capture in Kentucky. The Geographical Review, July, 1926.

Shaler, N. S.
A General Account of the Commonwealth of Kentucky, etc. Ky. Geol. Survey, Series II, Cambridge, 1876.
Description of the Preliminary Topographical and Geological Map of Kentucky, edition of 1877. Ky. Geological Survey, Series II, 1877.

Smith, Geo. Otis
Forty-seventh Annual Report of the Director of the Geological Survey to the Secretary of the Interior for the Fiscal Year ended June 30, 1926, pp. 53-61, Washington, D. C., 1926.

Tight, W. G.
Drainage Modifications in Southwestern Ohio and Adjacent Parts of West Virginia and Kentucky. U. S. Geol. Survey Professional Paper No. 13, Washington, 1903.

Wentworth, Chester K.
Geology and Coal Resources of the Middlesboro Basin in Kentucky. Ky. Geol. Survey, Series VI, Vol. XXIX, pp. 155-235. 1927.

# II.

## AN ISOTHRUSTIC HYPOTHESIS*

Phenomena of evident igneous origin when occurring in broad areas of thick and but slightly disturbed marine sediments have never failed to attract the attention of both the layman and the geologist. Such is the case in the eastern Mississippi valley where rocks and rock-structures exhibiting assuredly an igneous characteristic occur in a somewhat rectangular area about 150 miles in width and 100 miles in length. The total area involved is slightly in excess of 15000 square miles. The longitudinal course of this belt is approximately north 45 degrees east, from the vicinity of Jackson, Tennessee, to the region about Syracuse, New York (map AA′). As a unit, therefore, it is nearly parallel to the major axis of the Appalachian disturbance and the core of the lost Paleozoic continent "Appalachia" (map BB′). In general, it conforms to the shore line of the old continental block. Its geographic position is suggestive of a close relationship in origin with the Chestnut Ridge disturbance, in Pennsylvania and West Virginia, and its southwestward extension through Kentucky and southern Illinois which recently has been so graphically described by J. H. Gardner, under the title of "Stratigraphic Disturbance Through the Ohio Valley, Running from the Appalachian Plateau in Pennsylvania, to the Ozark Mountains in Missouri."[1] A summary consideration of these heretofore inadequately explained igneous criteria developing a regional hypothesis of crustal and subcrustal movements culminating at the close of the Paleozoic era is the purpose of this article.

The northernmost of the series of peridotite dikes, hereinafter to be described, occurs at Syracuse, New York (map No. 1). It was discovered as early at 1837 by Prof. Oren Root, as noted by T. C. Hopkins.[2] He thought it to be serpentine, and called it to the attention of Lardner Vanuxem through whom it found its way into the literature in 1839.[3] Notes on the geology of this

* Pan-American Geologist, Vol. XL, pp. 251-258, Nov. 1923.
[1] Bull. Geol. Soc. America, Vol. XXVI, pp. 477-483, 1915.
[2] Bull. New York State Museum, No. 571, p. 45, 1914.
[3] New York Geol. Surv., Third Ann. Rept. of Third Dist., pp. 160 and 238, 1839.

particular dike appear in thirty-two subsequent publications. With the discovery and detailed description of other dikes and dikic systems by N. H. Darton,[4] near Dewitt; by T. A. Conrad [5] at Little Falls, and by Lardner Vanuxem [6] near Ithaca, New York (map No. 2), the published literature (about 75 titles) concerning their lithological characteristics and origin has now reached the point where, it may be said, that they have been rather extensively discussed. Though all, with the exception of the Dewitt intrusion, were discovered and described before 1840, a keen interest in them, especially among geologists, has continued down to recent times. This is attested by the extended series of papers which has appeared concerning them. At the present time Prof. A. C. Gill, of Cornell University, is working on the petrographic character of the Ithaca dikes [7] while Mr. J. H. C. Martens, of the same place, has recently completed [8] a detailed investigation of them which will be published shortly. By way of summary concerning the group of central New York peridotites herein referenced, it may be said, that they exhibit a remarkable similarity lithologically, and that whereas early investigators were somewhat in doubt as to their age this is now quite generally accepted as of post-Carbonic date. They are not to be confused, however, with the Taconic dikes in the Lake Champlain region.

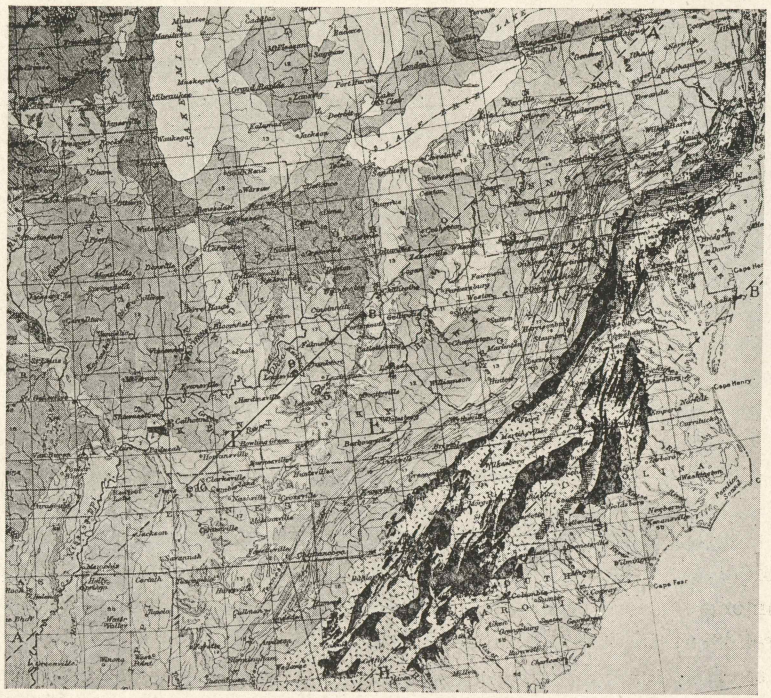
In 1905 the peridotite dike occurring in the Coal Measures of southwestern Pennsylvania, near Masontown (map No. 3), which has been discovered, as noted by Lloyd B. Smith,[9] as early as 1830 by residents of this section, was announced and briefly described by Prof. J. F. Kemp.[10] Two years later the first discussion was amplified by Kemp and Ross;[11] and in 1912 it was described anew and coupled with detailed mapping. The result of these investigations has been the determination of the post-Paleozoic age for the Masontown peridotites. Their close relationship lithologically with the central New York group and

[4] Am. Jour. Sci. (3), Vol. XLIX, pp. 456-462, 1895.
[5] New York Geol. Surv., 1st Ann. Rept., 3rd Dist., pp. 161-62, 1837.
[6] Ibid., 3rd Ann. Rept., 3rd Dist., p. 260, 1839.
[7] Correspondence of Dr. J. M. Clarke to the writer, Oct. 17, 1923.
[8] Correspondence of Dr. H. Ries to the writer, October 23, 1923.
[9] Pennsylvania Topog. and Geol. Surv., Rept. 1910-12, pp. 150-155, 1913.
[10] Bull. Geol. Soc. America, Vol. XVII, p. 691, 1907.
[11] Annals New York Acad. Sci., Vol. XVII, pt. ii, pp. 509-510, 1907.



the peridotites of Elliott County, Kentucky, has also been indicated.

The peridotite dikes of Elliott County, Kentucky, (map No. 4), occurring on the waters of the Little Fork of the Little Sandy River, in the northeastern part of the State, were described in 1892 by Diller,[12] and they have since been the source of some



GEOLOGY OF THE EASTERN UNITED STATES P. P. 71 MAP REDUCED

extended discussions. Peridotites were discovered in western Kentucky and southern Illinois (map No. 6) at an early date and were described by Ulrich and Smith [13] in 1905, and briefly referred to by J. F. Fohs [14] in 1907. They have recently been mapped in detail by S. Weller,[15] and reviewed and discussed by L. W. Currier.[16] They involve directly rocks of the upper Mississippian series, and indirectly rocks of the Pennsylvanian.

[12] Amer. Jour. Sci. (3), Vol. XLIV, p. 286, 1892.
[13] U. S. Geol. Surv., p. 36, 1905.
[14] Kentucky Geol. Surv. (III), Bull. 9, p. 68, 1907.
[15] Kentucky Geol. Surv. (VI), Vol. IV, 1921; also same, Vol. X, 1923.
[16] Illinois Geol. Surv., Bull. 41, pp. 237-244, 1920 and also Kentucky Geol. Surv. (VI), Vol. XIII, 1923.

Proceeding southwestward from western Kentucky no other igneous rocks are encountered until northeastern Arkansas is reached, where intrusive dikes and sills of late Cretacic age outcrop in disconnected patches from Little Rock to the vicinity of Hot Springs. They were described by J. F. Williams [17] in 1890, and by H. D. Miser [18] in 1913. As a group they penetrate the Pennsylvanian rocks, are certainly post-Carbonic in age, and are probably of late Cretacic origin. Their general strike is northeast to southwest. Lithologically they are principally syenites, and they appear to have very little in common with the peridotite dikes herein described east of the Mississippi River. They may have a closer genetic relationship with the peridotites of Pike County, Arkansas, which have also been shown to be quite dissimilar lithologically to the central New York and eastern Kentucky intrusions. The Pike County peridotites are also definitely somewhat younger, their age being placed at Late Cretacic by J. C. Branner,[19] since they penetrate Early Cretacic sediments. All of the Arkansas intrusives are regarded as definitely outside of and irrelevant to the hypothesis presented in this paper, and will receive no further consideration here.

A study of the dike material itself separately, and a comparison of the results of the several studies presented in the literature brings out a lithological, structural, and metamorphic similarity among the west Appalachian peridotites. The composite or general trend of the dikes referred to in New York, Pennsylvania, Kentucky, and Illinois is north 45° to 50° west. The central New York dikes involve rocks of Siluric and Devonic ages, but are authoritatively regarded as of post-Pennsylvanian origin. Those of Pennsylvania are taken to be post-Paleozoic, while those of eastern Kentucky and southern and central Illinois involve the upper Mississippian and Pennsylvanian sediments, and are undoubtedly post-Carbonic. Thus, all of these intrusions may be classified as of post-Carbonic or post-Poleozoic age in origin. While it may be pointed out that these intrusions might be as young as the Triassic or Cretacic periods, there appears to be no direct or indirect proof to substantiate such an assertion. On the contrary their occurrence is so remote geographically from

[17] Arkansas Geol. Surv., Ann. Rept. for 1890, Vol. II, 1891.
[18] Bull. U. S. Geol. Surv., No. 530, pp. 210-215, 1913.
[19] Arkansas Geol. Surv., Ann. Rept. for 1890, Vol. II, pp. 386-381, 1891.



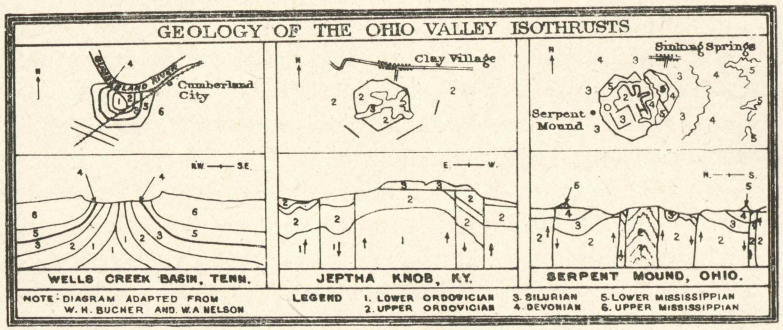
similar igneous rocks of undoubted Triassic and Cretacic ages as to invalidate the inference. No peridotites or other similar intruded rocks are known at present in Ohio,[20] southern Indiana,[21] or central [22] and western [23] Tennessee. Loose igneous boulders of evident Glacial of fluvatile origin occurring in these several regions have of course not been considered. The fact that the soft Cretacic sediments of western Tennessee are not known to be penetrated by igneous dikes must be held very favorable to the assumption that all of the Ohio Valley peridotites herein described are pre-Cretacic in origin and hence probably post-Paleozoic.

In central Kentucky (map No. 5) there occurs a rather broad district in which the Ordovicic limestones are cut more or less vertically along fault- and joint-planes by the deposits of fluorspar and barite with calcite in many cases associated. These veins while frequently less than a foot in thickness sometimes attain a width of 5 to 6 feet, and are in some cases of commercial importance. Radiating out from this central or enriched area, fluorspar is known to occur in commercial quality, though not in quantity, in six or eight Bluegrass counties. Lead (galena) and zinc (sphalerite) ores as inclusions are not infrequently found in these deposits of fluorspar and barite, and one such deposit at Gratz, in Owen County, Kentucky, has been extensively operated. In the Bluegrass district of Tennessee fluorspar, barite and galena are also known to occur.

In western Kentucky, in Livingston, Crittenden, Lyon, Caldwell, Trigg, and Christian counties, and in Pope and Hardin counties in southeastern Illinois, there occur very extensive deposits of fluorspar, the largest bodies of this kind in the eastern United States. The area of fluorspar mineralization is a unit with that in which the peridotites already referred to this section occur. As in central Kentucky, the fluorspar is found filling veins along joint- and fault-planes, particularly the latter, the entire region being very intricately deformed structurally as described by S. Weller.[24] Common ores of lead and zinc also are

[20] Correspondence of Prof. J. A. Bownocker to the writer, Sept. 21, 1923.
[21] Correspondence of Dr. W. N. Logan to the writer, Sept. 23, 1923.
[22] Correspondence of Mr. W. A. Nelson to the writer, Oct. 19, 1923.
[23] Correspondence of Dr. P. S. Smith to the writer, Sept. 29, 1923.
[24] Kentucky Geol. Surv. (VI), 1921.

found in association with some of these fluorspar deposits in western Kentucky and southern Illinois. The occurrence of fluorspar and barite veins in these fields of central and western Kentucky, and of southern Illinois, as above described, presents many points of similitude, the principal point of difference being that of quantitative deposit. The western Kentucky and southern Illinois deposits, which are by far the largest and most extensive, are of undoubted post-Carbonic age, the fracture lines of fluorspar intrusions involving in places Coal Measures sediments.




Geologists have long been familiar with the unique structure found in the Wells Creek Basin (map No. 10) on the Cumberland River, near Cumberland City, in Stewart County, in northwestern Tennessee. It has been recently briefly described by J. M. Safford;[25] and its general features have been mapped by W. A. Nelson.[26] This structure is a roughly pentagonal area three miles across in which the lower Ordovicic sediments have been forced up to the surface showing a section from the lower Ordovicic through the upper Ordovicic, Siluric, Devonic, and Mississippian strata. The interior area is extensively deformed. Two faults of slight extent border the Wells Creek Basin closely on the southwest.

Field investigations completed a year ago in the Serpent Mound region (map No. 8) of Adams County, Ohio, the results of which are still in manuscript,[27] have brought to light the fact

[25] Geology of Tennessee.
[26] Geological Map of Tennessee. Scale 1:500,000, Nashville, 1923.
[27] Walter H. Bucher.



that a somewhat similar structure to that occurring in the Wells Creek Basin of Tennessee is to be found at this point. The periphery of this structure is roughly polygonal in its interior, as well as its periphery, is intricately faulted. Nearly horizontal, undisturbed beds surround it. Its diameter is about four miles. The structure is not a simple dome. Along the roughly circular periphery Waverly beds have been down-faulted in some places as much as 500 feet, while in the center the shale and limestones of the Richmond (Ordovicic) series have been thrust up 200 to 300 feet. Rocks of Ordovicic, Siluric, Devonic, and Mississippian age are shown in this section, the youngest ones involved in the structure being those last named. The force responsible for the structure was directed radially outward essentially at one point from the earth's interior.

As a result of field investigations recently completed in Shelby County, Kentucky, for the Kentucky Geological Survey, following the disclosure of the nature of the Serpent Mound structure, a third somewhat similar structure has been detailed by W. H. Bucher.[28] It is known as the Jeptha Knob (map No. 9) and is located slightly southwest of the center of the Bluegrass region of Kentucky. The Jeptha Knob structure is roughly polygonal, slightly less than three miles in diameter and is faulted about its periphery. Ordovicic beds within this structure are uplifted as by a plug between 100 and 200 feet. The top of the uplift has been truncated and on these unconformable strata horizontal beds of upper Siluric age are now found undeformed.

No other structures closely similar to these three are known to exist in the eastern Mississippi Valley unless those somewhat remote doming anticlines described by Maurice Thompson[29] in Carroll County, and by Elrod and Benedict[30] and by E. M. Kindle[31] in Wabash County, in Indiana, develop so to be following detailed geological mapping.

A comparison of the Wells Creek Basin, Jeptha Knob, and Serpent Mound, *isothrustic* structures, here so named for the first time, present a number of interesting points of similarity

[28] Kentucky Geol. Surv. (VI), Vol. (in press), 1923.
[29] Indiana Dept. Geol. and Nat. Res., 17th Ann. Rept., pp. 177-186, 1891.
[30] Ibid., pp. 220-238.
[31] Ibid., 28th Ann. Rept., pp. 397-487, 1903.

and dissimilarity which may be summarized as follows: (1) Area involved is small, 5 to 10 square miles in each case; (2) structure is restricted, deformation of even bedded sediments occurring only in the immediate vicinity; (3) no regional uplift appears to have accompanied any of these structures; (4) structural deformation within each of these concentric *isothrusts* is great, the faulted pattern of each, insofar as it is known, being similar as regards periphery, and to some extent as regards interior; (5) no igneous intrusions, or igneous emanations, are definitely known to involve any of these three *isothrusts*. Points of dissimilarity may be noted as follows: (1) The Wells Creek Basin and the Serpent Mound *isothrusts* involve rocks which are not known to be younger than Mississippian, whereas the Jeptha Knob *isothrust* is plainly somewhat older, having been formed, and planed down prior to the deposition of Siluric sediments which now cap it horizontically; (2) Wells Creek Basin [32] *isothrust* is an abruptly doming anticline. Occurring in a limestone region it has developed into a topographic basin syncline. On the other hand the Jeptha Knob *isothrust* (1176 feet A. T.) is in reality a monadnock rising 300 to 400 feet above the surrounding plateau. The Serpent Mound *isothrust* (980 feet A. T.) is topographically, however, simply a knob in a country of knobs many of which are 200 to 300 feet higher.

A digest of the various structural, stratigraphic, petrologic, and geographic relationships exhibited by the dikic and *isothrustic* disturbances in the region heretofore outlined leads to the following postulate, a summary of which is submitted as an explanation sufficient to account for these several occurrences: (1) The occurrence of widely distributed yet similar post-Carbonic peridotites, and three somewhat similar isothrustic structures within a narrow belt paralleling the Appalachian folds, is undoubtedly to be associated with the Appalachian Revolution. The only other great continental disturbances with which any of these igneous phenomena might be connected are the Taconic and the Laramide. The first of these is manifestly impossible, since these rocks and rock structures in most instances involve sediments of Pennsylvanian age. The second is dismissed be-

[32] The altitude of the Louisville and Nashville Railroad rails in Cumberland City closely adjoining on the northeast is 382 feet A. T.



cause of absolute lack of evidence in the field. Assuming the Piedmont belt of the Atlantic slope as approximately the central core of the lost continent "Appalachia," the various phenomena above described and referred to are regarded as isostatic criteria resultant from the crustal movements which culminated in the Appalachian Mountain system.

With the downward movement of Appalachia, all crustal and basement rocks well into zone of permanent flowage are conceived to have moved to the northwest and to the southeast on flattened arcs, the horizontal radii of which were about 160 miles in length. Evidences of such movement to the southeast are covered by the comparatively recent, unconsolidated sediments of the coastal plain and the Atlantic Ocean. Evidences of these movements to the northwest, however, are plainly apparent in the igneous rock and rock-structures which have just been referenced. The entire rectangular area in which these igneous intrusions and *isothrustic* structures are found is regarded as underlain at depths of but a few thousand feet by a great isostatic igneous magma of which these are but some of the surface criteria. This is held true although considerable oil-well drilling in this region to depth less than 3500 feet has been productive of results to the contrary. How many other intrusions and disturbances were at the same time initiated but failed to reach the surface, or reaching it have been effectually blanketed by late Mesozoic and Cenozoic sediments will never be known.

The very apparent suggestiveness of incipient volcanic activity in the *isothrustic* structures forming the Wells Creek Basin, Jeptha Knob, and Serpent Mound will be recalled by anyone who has visited them in the field. The occurrence of horizontally disposed sediments of Siluric age on top of the Jeptha Knob, in Shelby County, Kentucky, is also suggestive of the fact that the line AA′ (see map) which parallels the core of the old "Appalachia" BB′ has been one of structural weakness since very ancient times—early Siluric at least. It leads to the inference that broad crustal movements which finally spent themselves in the Appalachian mountain-making movement had their inception somewhat earlier in the Paleozoic era than has generally been assumed.

# III.

## UNIQUE DEVONIC SANDBAR*

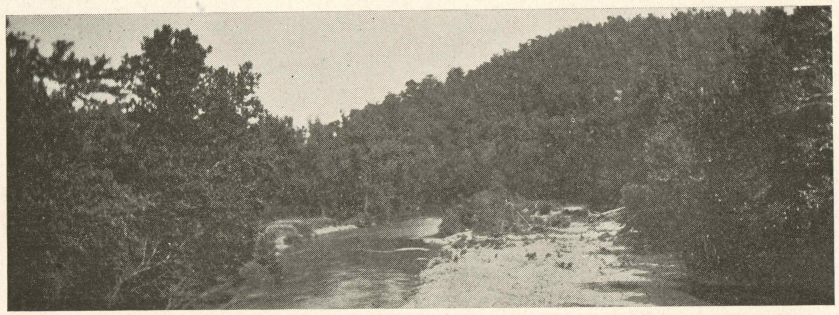
The discovery of an odd, local unconformity in the Late Devonic strata of Cheatham County, Tennessee, at a point where the Harpeth River breaks through the western highland rim is recorded as one of a number of instructive results of the field investigations undertaken by the writer in this region during September of the current year. The unconformable area sets in at a point two miles due north of Kingston Springs Station. It extends north 40 degrees west, somewhat as an ellipse, for about three miles and is slightly less than two miles wide. Throughout this area the Chattanooga shale is absent. Basal beds of the Fort Payne formation (Lower Mississippian) rest directly upon the Hardin sandstone (Late Devonic). Because of its isolation and geographic position, only 16 miles west of Nashville in air-line, this local unconformity is of regional significance.

The southeastern terminus of this unique Devonic sandbar, or insular area, is slightly below the mouth of Dog Creek on the Harpeth River. The northwest end is slightly above the juncture of Sulphur Creek with the Harpeth River. That Chattanooga shale, with a thickness ranging from 8 to 15 feet, is found near the mouth of Dog creek, on the head of Scott Branch, just above the mouth of Mound Creek, and on the lower waters of the Middle and North forks of Groves Creek, and Sulphur Creek, all on the northwest side of Harpeth River. On the southwest side it is found, in a similar thickness crossing the Harpeth River three-fourths of a mile above the mouth of Dog Creek, and in several low falling branches southeast of "The Narrows." At the Narrows it occurs with a thickness of about 3 feet, and rapidly becomes thinner towards the northeast, failing entirely at the low gap 1000 feet distant.

On the lower waters of Fishtrap Hollow the Chattanooga shale is missing entirely, but at a point about 2000 feet from the mouth the shale is found in the bottom of the branch as very thin leaves ranging from half an inch to 3 inches in thickness, inter-

*Pan-American Geologist, Vol. XL, pp. 333-337, Dec., 1923.

calated between layers of the Hardin sandstone which at this point is coarsely conglomerate. The interbedded sandstone and shale formation is here about three feet in thickness. The Hardin sandstone at this point is fossiliferous, containing imperfect casts of brachiopods and crinoid stems, and an occasional fish tooth. It also shows worm tracks and sun-cracks. Sand-grains partly of chert and partly of crystal quartz, with a slight intermingling of iron-stone pebbles up to the size of a pea, and some small



HARPETH RIVER AT MOUTH OF DOG CREEK

geodiferous inclusions, make up the body and characteristic of this conglomerate which at this point is divided into several layers ranging from 2 to 5 inches in thickness. The top of separate layers is coarsely conglomerate. The Hardin standstone here is overlain by about one foot of black compact sandy shale undoubtedly a correlative of some part of the Chattanooga shale on a paleontological basis. It contains the usual Lingulas and also a great many Ostracods. It differs widely, however, lithologically, since it lacks the usual compact, jet-black, fissile characteristic.

The Hardin sandstone is underlain by the fossiliferous Pegram limestone (Mid Devonic), and overlain, where the Chattanooga shale is cut out, by massive, siliceous beds of the lower Payne formation. Most of the quartz and chert pebbles in the Hardin sandstone are rounded and small, indicating much reworking. Occasionally, however, large chert- and quartz-pebbles occur in angular form, indicating closer sources for this particular material. One flat elliptical chert pebble three inches in length and half an inch in thickness was found.



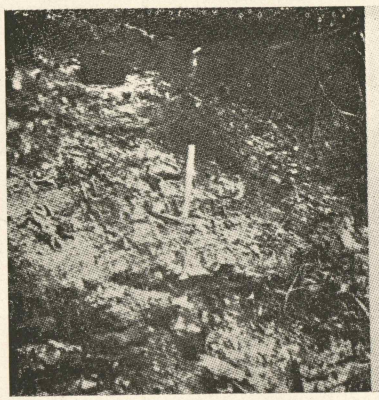
An excellent view of this unconformity (see plate xxxiii, figure B) between the Hardin sandstone and the basal Payne formation is found at an elevation of 600 feet along the cliff above the road 200 to 500 yards below the mouth of Fishtrap Hollow on the north side of Harpeth River. Here the Pegram limestone forms a pronounced wall 20 to 30 feet high, and is overlain by the Hardin sandstone which at several points of measurement was found to be three feet in thickness. Directly above it the lower Payne beds set in, the Chattanooga black shale being entirely absent. At three points of outcrop, one fresh and two weathered, the line of junction between the Hardin sandstone and the overlying Payne formation was definitely found. At each of the weathered points of outcrop the Hardin sandstone was found divided into several layers ranging from three to six inches in thickness. The sandstone here is fine-grained and tough. Iron in relatively large amount is present as a cement, and also as a brown or iron-stone top-coating, indicating a silting up and possible exposure as a sand- or mud-flat shortly following deposition.

At the point of fresh outcrop the upper part of the Hardin sandstone appears to have been whipped up as the first Payne sediments came in. Here the line of demarcation is not clear and the two are somewhat intermixed, a fine, gray-green, sandy shale, lithologically identical with adjacent beds of undoubted Payne age, being found interbedded as irregular lumps within the conglomerate sandstone. Along this cliff the Hardin sandstone appears to be more coarsely conglomerate, several flat pebbles 3″x2″ having been found.

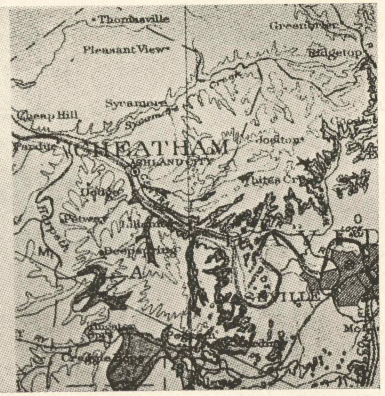
No other areas, so far as the writer is aware, exhibiting so marked an unconformity as this one, are known in so high a position on the Rutherford dome of central Tennessee. At many points of outcrop along the Cumberland River, to the northwest, and along the Harpeth River, to the southeast, the Chattanooga shale is found, its thickness ranging from ten to twenty feet.

Slightly to the west of the area occupied by this Harpeth River sandbar, in Dickson County, wells drilled for oil and water show the Chattanooga shale to have a somewhat uniform thickness of twenty to twenty-five feet. At all points so far as is known, the Hardin sandstone underlies the Chattanooga shale.

The nearest areas showing an absence of the black shale are found at points fifty to seventy miles distant to the southwest in Wayne, Hardin, and Lewis counties, Tennessee, and these have been described by J. M. Safford.[1] In the Waynesboro Quadrangle the maximum thickness of the Chattanooga shale is given by H. D. Miser[2] as twenty-two feet, and the underlying Hardin sandstone as fifteen feet. The Chattanooga shale is present in the Wells Creek Basin on the Cumberland River, just southwest of Cumberland City, in Stewart County, Tennessee. As interpreted from many logs of wells drilled for oil and gas at short distances north of the Tennessee line in Warren, Simpson, Logan, Todd, Christian, and Trigg counties, Kentucky, the black shale is always present, averaging thirty to forty feet in thickness. It has been reported, however, by C. O. Dunbar,[3] as locally absent



JUNCTURE OF HARDIN SANDSTONE AND PAYNE FORMATION




CHEATHAM CO., TENN., UNCONFORMITY WEST OF (A)

in the section due to erosion in some parts of the West valley of the Tennessee River, though generally present with a thickness ranging from two to ten feet.

Interesting speculations arise as to the cause of this little

[1] Geology of Tennessee, pp. 329-337, 1869.
[2] Tennessee Geol. Surv. Bull. 26, p. 23, 1921.
[3] Tennessee Geol. Surv. Bull. 21, pp. 91-92, 1919.



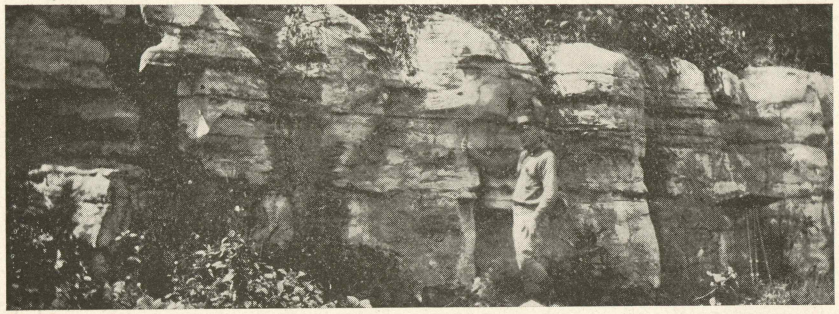
Late Devonic sandbar, or island, at so high a position on the Rutherford Dome. Detailed structural investigations of this region, now complete, indicate that this sandbar occupies a crestal position on a doming anticline which plunges north forty degrees west. The top of this dome crosses Dog Creek half a mile above its juncture with the Harpeth River. At the highest point of the dome, the Chattanooga black shale is present in regular position above the Hardin sandstone. The Hardin sandstone in the bar, or insular area, where the Chattanooga black shale is absent, is somewhat thicker than elsewhere in this region. In typical exposures in this region generally at points removed from this old sandbar, it is less than a foot in thickness. Its occurrence on the anticline above described in crestal positions suggests the probability of Late Devonic folding for this restricted area, with the whipping up of the Hardin conglomeratic sands into an off-shore mound.

The absence of criteria establishing beyond doubt pronounced subaereal erosion on this little sandbar, when taken together with the intercalation of leaves of the Chattanooga shale with the sandstone, as found in Fishtrap Hollow, and the thickening of the black shale in all synclinal areas, suggests that this slightfolding was initated during the deposition of the Hardin sands and continued on during the subsequent shale epoch, shutting out the deposition of the Chattanooga black muds. This explanation seems to fit the findings in the field better than the postulate that the black shale was deposited in part or in whole, and then subsequently removed by erosion, during or following uplift. The extremely shallow nature of the reeking vegetal seas of the Chattanooga stage in this region certainly, and in surrounding much wider areas generally, is attested. The source of the large chert pebbles in the Hardin sandstone may have been the insular area occupied by the Rutherford dome, as noted by J. J. Galloway,[4] but the source of the rather large angular quartz-pebbles is not so easily traced.

At the close of the Devonic period the upper black shale members of this system being absent within this unconformable area, Mississippian sediments came in to a thickness of at least

[4] Tennessee Geol. Surv., Bull 22, p. 71, 1919.

400 or 500 feet. Nothing now existent in this field may be taken to indicate definitely a submersion of the region during the formations of the coal measures, or in subsequent time, though such was probably the case. With the Early Cretacic peneplanation it came to border closely upon the interior seas (Eutaw



PEGRAM LIMESTONE NEAR PEGRAM
DEVONIC SANDBAR IN TENNESSEE

and Tuscaloosa stages) of this period, but probably with a much different regional drainage pattern than at present. Possibly in the post-Mississippian, but more probably in early post-Carbonic times, the region was again subject to folding along the same northwest southeast line as before, the culminating high-point of the second folding occuring adjacent to the lower waters of Dog Creek.

The subsequent geologic history of this region is indicated as follows: Towards the end of Cretacic time, uplift and tilting to the west produced a plateau. Base-leveling agencies again set to work with the result that the region was reduced to a peneplain during Eocene times. Somewhat later, perhaps in mid-Cenozoic times the Harpeth River region was once more uplifted, the Eocene peneplain being the plateau now seen in the accordance of summit elevations of the ridges of this part of the Western Highland Rim. Erosion since this time has given this region its present topographic figure and marked relief.

# IV.

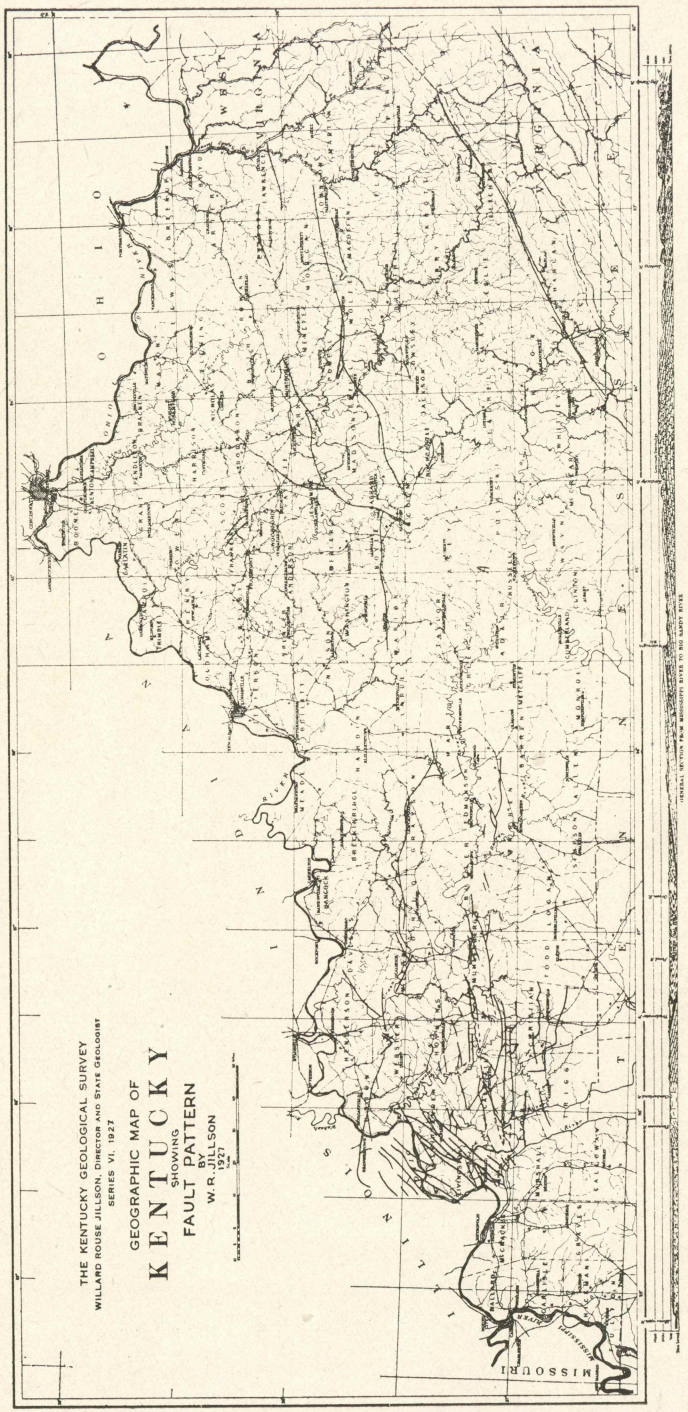
## FAULT PATTERN OF KENTUCKY*

Detailed structural investigations which have been carried on by the Geological Survey during the last few years throughout Kentucky have resulted in the outline of a new fault pattern for the State. Whereas previously Kentucky was thought to be crossed in general from west to east by a single line of faulting and folding, it is now definitely known that there are two statewide and well-defined lines of fracture and flexture. These two lines of disturbance are separated by belt varying in width from 10 to 30 miles. Excepting a restricted area in western Kentucky, in Livingston, Crittenden, Lyon, Caldwell, and Hopkins counties, where the country is extensively fractured, this elongated inter-fault area or block is but slightly disturbed.

The Rough Creek disturbance in western Kentucky, the Kentucky River faults of the Eastern Blue Grass district and the Little Sandy fault in eastern Kentucky outline the course of the northern line of fracture. The southern line of faulting progresses eastwardly from beneath unconsolidated Cretacic and Cenozoic sands and gravels of Marshall county, into southern Caldwell, Hopkins, Muhlenberg, Edmonson, central Hart, Marion, Lincoln, and Garrard counties. From Estill County it proceeds slightly northeastward as the Irvine-Plant Creek fault and the Warfield fault.

Each of these major lines of east and west disturbance are now recognized as normal faults for the most part, and downthrow generally being on the south side. They are almost always closely paralleled on the south by anticlinal structure. The lineal extent of these two lines of disturbance totals about 650 miles within Kentucky. Their regional economic influence has been great, particularly in the coal fields of eastern and western Kentucky where low measures have been brought close to the surface. The major oil and gas fields of eastern Kentucky are closely associated with these disturbances.

* Pan-American Geologist, Vol. XLI, pp. 31-32, Feb., 1924. Paper presented before American Association for Advancement of Science, Cincinnati Meeting, 1923.




SKETCH SHOWING FAULT PATTERN IN KENTUCKY



In western Kentucky a radial pattern of principally normal faults appear to center under southern McCracken and northern Graves counties, in the Jackson Purchase. Faults leading from this focus strike almost due north in southern Illinois, opposite McCracken County, Kentucky, slightly east of north in western Livingston County, north 45 degrees east in Crittenden and northern Caldwell counties, and nearly due east in southern Caldwell and Lyon counties. The fault pattern here, although not completely detailed at present, has an appearance suggestive of a collapsed doming structure which may have been upwards of 150 miles in diameter. If this indeed proves to be the case it will have been one of the largest low angle domes in the Mississippi Valley not excepting the Jessamine and Rutherford domes of the Cincinnati Arch.

In central Kentucky, north of the Kentucky River, there occurs a number of normal faults in Franklin, Scott, Fayette, Jessamine and Bourbon counties whose composite strike is not far from due north and south. Excepting their effect on the soils of these regions, their economic influence has been small. The largest disturbance in Kentucky is the Pine Mountain overthrust which lies close to the southeastern border of Kentucky in Whitley, Bell, Harlan, Letcher, and Pike counties. This fault is about 110 miles in length in Kentucky. It passes out of the State into Buchanan County, Virginia, on the Northeast, at the "Breaks of Sandy." Although not the longest in Kentucky it is the most profound and unified disturbance in the State and is of major economic importance in the portion of Kentucky which it traverses. It involves virtually the entire late Devonic, Mississippian, and lower Pennsylvanian sequence of this region. Where well developed this fault brings rocks normally 3000 to 6000 feet below draining to the surface. Structurally, it shows a sag, or hinge, in the vicinity of Pine Mountain Postoffice, the structure of the rocks from this point rising to the northeast and to the southwest.

# V.

## NEW RELIEF MAP OF KENTUCKY*

The completion in Kentucky within the last few years of a number of strategically located topographic sheets (scale 1:62,500) has resulted in some new detailed conceptions of physiographic relations. These have been well brought out by John H. Renshawe in a new relief map of Kentucky, scale 1:500,000 which will be published shortly in tints and shades of brown by the U. S. Geological Survey, Topographic Branch. This map is based chiefly on the new topography of Kentucky and the personal field work of Mr. Renshawe who had charge of topoghaphic work in Kentucky some years ago. The new map replaces Edwin E. Howell's relief model of Kentucky made in 1893, scale 1 inch equals 4 miles. This old model is now in the Museum of the University of Kentucky, at Lexington.

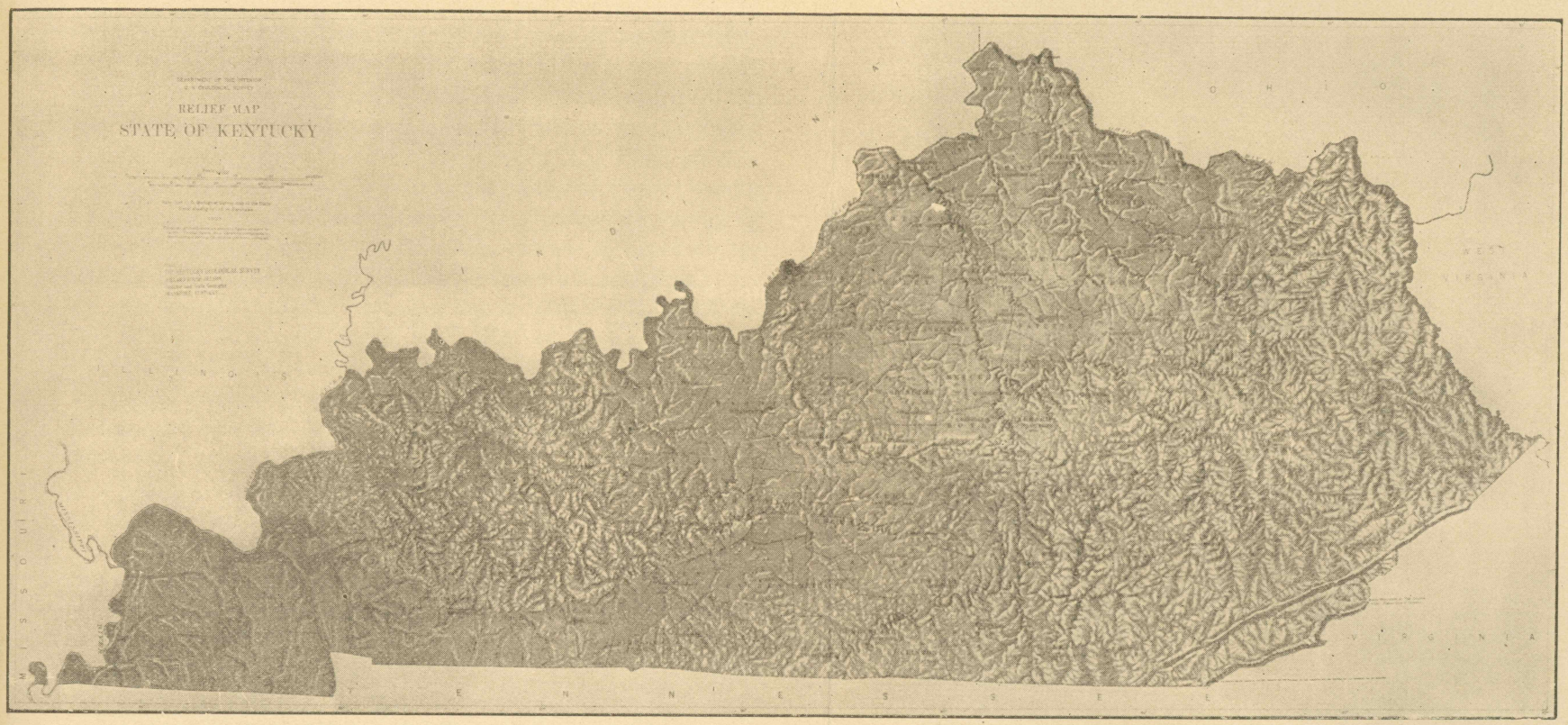
The first geological reconnaissance of Kentucky, made in 1838 by Dr. W. W. Mather, served to indicate the six physiographic provinces of Kentucky. These are: (1) Mountains, (2) Blue Grass, (3) Knobs, bounding the Blue Grass on the East, South and West, (4) Mississippian Plateau, (5) Western Coal Field, and (6) Jackson Purchase, or all west of the Tennessee River. Mather did not give these regional names which have now become standardized, nor did he define the boundaries. This has been the work of more recent investigators.

The chief contributions found in the Renshawe map are the following: (1) Extension of the "Mountain," or hill dendritic, figure to southern and central Kentucky; (2) a clear definition of the "Muldraugh's Hill" escarpment of the knobs surrounding the Blue Grass district; (3) a detailing of the entrenchment of the Kentucky River in the well-defined Blue Grass plateau; (4) a fine delineation of the gorge of the Green River and its tributaries in the "Karst" portion of the Mississippian plateau; (5) definite outline of the "Dripping Springs" escarpment which impinges on the southern and southeastern borders of the

* Pan-American Geologist, Vol. XLI, pp. 75-76, Feb., 1924. Paper presented at the Cincinnati meeting of the American Assoc. Adv. Sci., December 28, 1923.

Western Coal Field; (6) a detailing of the low, rounded hills and broad, filled valleys of the lower Green River and its tributaries, and portions of the Ohio River in the Western Coal Field; (7) a marked contrast in the elevation of the Cumberland Mountain and plateau regions with those of other portions of the State.

Kentucky is at present slightly less than one-half topographically base-mapped, and consequently there are broad areas in which the detailing of the topography will greatly assist in the accurate preparation of future model relief-maps of the State. It is not probable, however, that this new detailing will effect any material change in the broad, regional, physiographic features as presented on this new map, which is by far the best that has ever been prepared.




NEW RELIEF MAP OF KENTUCKY

This exclelent map was prepared by John H. Renshaw of the United States Geological Survey in 1924, the Kentucky Geological Survey co-operating

# VI.

## KENTUCKY CANNEL COALS*

Although Kentucky cannel coals are the largest in deposit in the eastern United States, relatively little has appeared in geological literature covering them except casual references. Ranking high in quality they were first mined near Cloverport, on the Ohio River, in 1855. Since then, at one point or another, they have been operated almost continuously down to the present time. The volume of Kentucky-produced cannel coal in 1910 was 76,000. tons.[1] The best known cannel coals of Kentucky are: (1) Cannel City deposits of Morgan County, (2) Boghead cannels of Carter County, (3) Abbott Creek cannel of Floyd County, (4) Chenoa cannel of Bell County, (5) Hunnewell cannel of Greenup County, and (6) Breckinridge cannels of Breckinridge and Hancock counties. Many other districts are producing cannel coal but generally as part of a major bituminous operation.

Western Kentucky cannel coal, although first to go on the market, is of limited extent, the described deposits not exceeding 10 distinct exposures, all of which are widely separated. Listed by counties they are: Hancock 3, Breckinridge 1, Union 2, Crittenden 1, Christian 1, and Edmonson 1.

Eastern Kentucky, on the other hand, contains cannel coal of some grade in nearly every county. The literature of the Kentucky Geological Survey contains descriptions of 245 different bed sections separated into counties as follows: Greenup, 4; Carter, 10; Lawrence, 2; Elliott, 8; Morgan, 19; Menifee, 2; Wolfe, 1; Magoffin, 23; Johnson, 7; Martin, 5; Pike, 6; Floyd, 11; Knott, 6; Letcher, 12; Harlan, 21; Bell, 6; Whitley, 7; Knox, 19; Laurel, 1; Pulaski, 2; Clay, 10; Leslie, 13; Perry, 11; Johnson, 4; Owsley, 2; and Breathitt, 33.

Personal field investigations of the writer during the past several years, on the coals of Kentucky, coupled with a summary of the literature, leads to the following conclusions:

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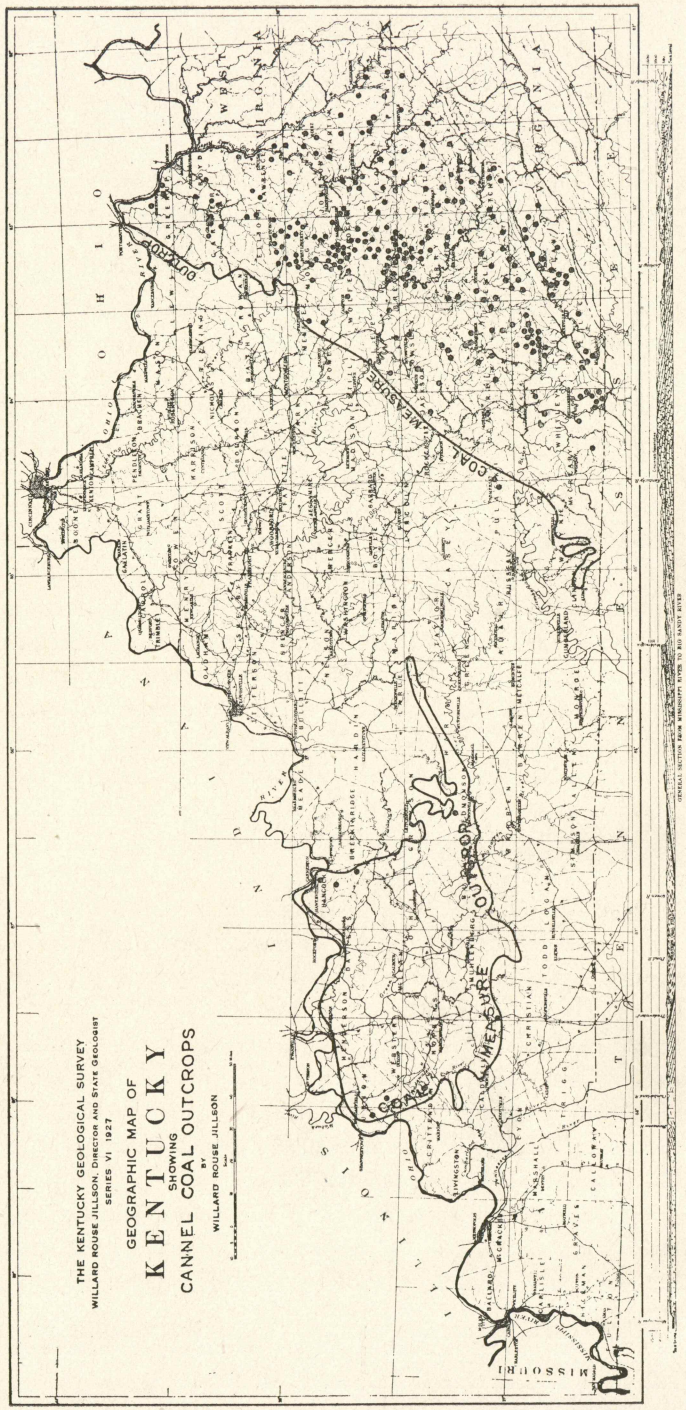
* Pan-American Geologist, Vol. XLI, pp. 97-98, March, 1924. Paper presented before American Association for Advancement of Science, Cincinnati Meeting, December 28, 1923.

[1] Bull. U. S. Geol. Surv., No. 659, p. 83, 1918.




LOCATION OF CANNEL COAL DEPOSITS IN KENTUCKY



1. The principal body of cannel coal in Kentucky occurs in a broad interior area situated about 15 to 20 miles back of the extreme western border of the Eastern coal-field.

2. Cannel coals occurring along the western border of the Eastern coal-field constitute a unit province which is of secondary importance from qualitative and quantitative standpoints.

3. Western Kentucky cannels are of distinctly a third class order.

4. Cannel coals are rather uniformly distributed throughout No. 1 district of the Eastern coal-field.

5. The commercial cannel coals of Eastern Kentucky (cannel in whole or in part) are of the following: Van Lear, Elkhorn, Whitesburg, Fire Clay, and Limestone.

6. Cannel coals are frequently associated with cannel and carbonaceous shales which in turn are frequently of a marine or brackish-water origin.

7. Cannel coals and cannel shales frequently blend together, or separate.

8. The area of a thick cannel coal deposit is generally small; the area of thinner cannel coals, or seams carrying a part cannel, is generally much broader.

9. The important cannel coals of eastern Kentucky are much higher in the stratigraphic column than in western Kentucky.

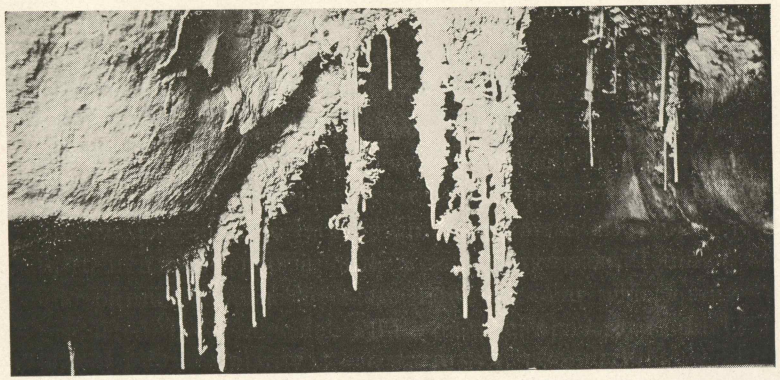
10. In Kentucky the cannel coals are all of Pottsville age, the commercial cannels extending up from the Wayland coal through the Limestone coal.

# VII.

## PRIMEVAL TRACTS IN KENTUCKY*

Kentucky as a State is fully inhabited, though not thickly populated like many of the Commonwealths along the Atlantic seaboard. Contrary to a somewhat general, but erroneous, impression found in other parts of the United States, particularly in New England, no large portions of this State remain to-day in their natural or original condition as regards its fauna, flora, and physiography. There are, however, some widely separated, restricted areas in which virgin natural conditions still nearly obtain.

The physiography of these isolated regions has not been altered. The flora closely simulates the original, but the fauna, in most instances is either greatly reduced in both number and species, or reduced and otherwise altered by the introduction by man of new wild or domesticated groups. The principal areas which approach a natural condition are:



STALACTITES, MAMMOTH CAVE REGION

(1) A few swamps and lowlands bordering the Mississippi River in the "Purchase," or old Gulf Embayment region west of the Tennessee River;

(2) A few recently discovered, or undiscovered, caves in the Ordovicic and Mississippian limestones of central, southern and eastern Kentucky;

(3) The topmost craggy ridges of the Pine and Cumberland Mountains;

(4) A few timbered tracts in Harlan, Perry, Leslie, Knott, Breathitt, Pike, and Martin counties, which tracts are for the most part quite small;

(5) A few disassociated, but geologically similar, dells, coves and hollows along the outcrop of the Pottsville Conglomerate (Pennsylvanian) in eastern Kentucky on the western edge of the Eastern coal-field;

(6) A few hollows in the vicinity of the outcrops of the Cypress sandstone (Mississippian) in western Kentucky, notably in Grayson and Breckinridge counties; and

(7) Widely scattered throughout the State, particularly in remote parts of Elliott, Powell, Wolfe, Lee, Jackson, Whitley, McCreary, Pulaski, Rockcastle, Laurel, Edmonson, Grayson and Clinton counties, there are restricted areas in the box canyons of entrenched streams which simulate natural conditions. These canyons were from the beginning too small to allow a large natural forestration. The amount of timber now found in them is essentially the same as the original. The stream in many cases occupies the entire floor of the canyon, especially at high water, and does not allow of cultivation. Streams on which this sort of thing occurs are the gorges and headwaters of the Little Sandy River in Elliott County; the gorge and headwaters of the Cumberland River, in Whitley, McCreary, Wayne, and Pulaski counties; the gorge and head-waters of the Rockcastle River, in Rockcastle, Jackson, Pulaski and Laurel counties; headwaters of the Red River, in Powell and Wolfe counties; some small tributaries of the North Fork of the Kentucky River, in Lee and Jackson counties, portions of the Nolin River, Bear Creek, Big Clifty and Rough creeks, in Grayson, Edmonson, Hardin and Breckinridge counties; and on Ill Will and Indian creeks, in Clinton County. The greatest change in all of these regions, and in fact in the State generally, has been in the removal of the larger native forest trees and the extinction of certain faunal species.

There are notable modifications of the fauna, flora, topography and soil. With the exception of the swampy lowlands

* Pan-American Geologist, Vol. XLI, pp. 169-175, April, 1924. At the time this paper was written the author was chairman of the Kentucky State Park Commission.



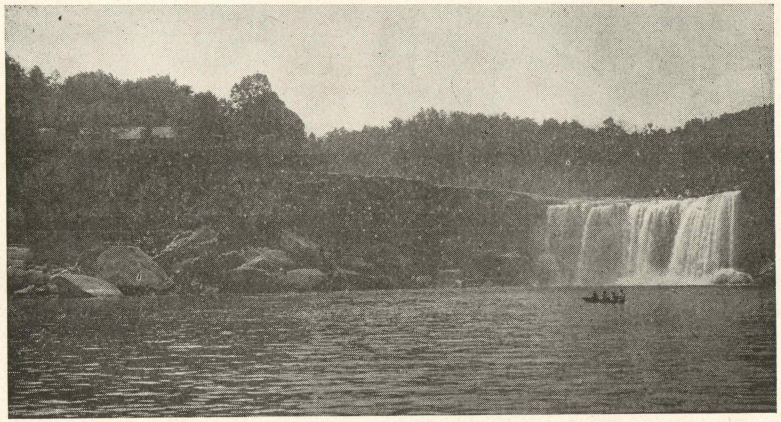
which border the Mississippi River, in extreme western Kentucky, all of the primeval regions which have been indicated are the roughest and most inaccessible of the state. Physical relief varies between 250 and 1000 feet in most instances. In the case of the restricted Pine and Cumberland Mountains regions, altitudes, by far the highest in the state, ranging between 2,500 and 4,000 feet, are found. The soil, where any occurs at all, is thin and poor. In many cases, as in the canyons of the streams and along the crests of the mountains, the absence of soil will be noted by the naturalist investigator and nature lover.

The animals inhabiting these regions are the original fauna, minus the deer, bear, bison, wolf, elk, panther and beaver. The bear, broadly migratory by instinct, is occasionally reported in the counties along the Pine and Cumberland mountains, where he is undoubtedly an immigrant from the adjacent Blue Ridge and Smoky Mountains of Virginia and North Carolina.

The native birds which are now extinct are the passenger pigeon, the paroquet, and some species of the eagle. The raven once here in great numbers, is now virtually unknown. Oddly enough, in the place of these extinctions, and occurring not infrequently in the most inaccessible and isolated portions of the state where the fullest simulations of original conditions still prevail, the careful observer will note occasionally the path of one or more of the various domesticated animals and fowls. This is particularly true of unpenned household and farm-yard species. The roaming instinct is much more ancient than is that of domestication. Nature-loving companions of man are the domesticated dog, the cat and the turkey. All of these, including man, occasionally revert to type.

Large, unpolluted waters, as such, really do not occur in the State of Kentucky, due to the fact that the State is almost entirely inhabited. Kentucky does not have any natural lakes entirely within its borders, though Reelfoot Lake, caused by the New Madrid earthquake of 1811, tips into the southwestern part of Fulton County from Tennessee. It is a low shallow lake located in the Mississippi River bottoms. This State does have, however, a few artificial lakes of small area. Notable among these are the Pound Gap Lake at Jenkins, Fern Lake at Middlesboro, South Park Lake at South Park, Jefferson County, Cum-

berland Lake at Kuttawa, the Lexington Reservoirs, and a large number of smaller mining, railroad, sink-hole and stock and fish ponds of wide distribution. None of these contain unpolluted waters, except the Lexington Reservoirs and Fern Lake, each of which respectively is used for drinking purposes by the cities of Lexington and Middlesboro.



CUMBERLAND FALLS, FROM THE GORGE

If, however, the term, unpolluted, may be interpreted to mean such flowing waters as are in a nearly natural condition, with only mountain farms affecting their drainage basins, portions of the headwaters of the following streams may be listed as the most typical:

Middle and South Forks of the Kentucky River, in Leslie and Clay counties,
Martin Fork, in Harlan County,
Clover Fork, in Letcher County,
Green River, in parts of Lincoln County,
John Creek, in Pike County,
Beaver Creek, in Knott County,
Cumberland River, in Whitley and McCreary counties,
Browney Creek and Clear Creek, in Bell County.

Besides these, which are really in a class by themselves, there are hundreds of small creeks and bhanches in Kentucky which are unpolluted by city, manufacturing, or mining drainage. Individual instances of this sort of stream which is always restricted in volume and extent, can be found in almost every county of the State. The water strictly speaking, however, is not unpolluted since the areas are generally used during some portions of the year at least for grazing stock.



During the period of the settlement of Kentucky, and for many years following, the countless springs of this State were rightly regarded as a source of unpolluted water. Many of the springs were very large, veritable meadow brooks, and in some few instances fair-sized creeks at their point of issuance from the bedded Ordovicic and Mississippian limestones. About such springs, especially in the fertile Bluegrass and Pennyroyal farming areas, towns quickly sprang up using the cold, clear waters so copiously bestowed by nature for drinking as well as other purposes. Lexington, Versailles, Georgetown and many other places could be cited as instances of towns that placed an early dependence upon large springs for their water supply. In due course, and following the growth and centralization of town populations, such town springs became polluted with various forms of sewage and plainly showed their local and surficial source. Epidemics in some notable instances, is at Lexington and Georgetown, followed with the result that these waters have now in most cases been abandoned. Many deep-seated and mineral springs such as those of Crab Orchard, Big Bone Lick, Blue Lick and Dawson Springs, however, have retained their original purity and are of much medicinal value.

Kentucky is famous for its cavernous regions. Here is found not only the largest cave, Mammoth Cave in Edmonson County, but also a very large number of smaller caves distributed over a broad area of central, southern and northeastern Kentucky. The Mammoth Cave region has received a larger recognition in the descriptive literature pertaining to the State than any other single feature. Upwards of one hundred books, pamphlets, and articles have been published pertaining to this wonderful portion of Kentucky.[2] This region is practically a unit with that known as the Mississippian Plateau in which it has been figured there are between sixty and seventy thousand caving sink-holes.[3] It is the region in which the pure and semi-pure limestones of Mis-

[2] Kentucky Geol. Surv. (6), Vol. X, p. 143, 1923.
[3] Science, Vol. LVIII, pp. 184-185, 1923.

sissippian age (Gasper and Ste. Genevieve) are exposed, or are close to the surface.

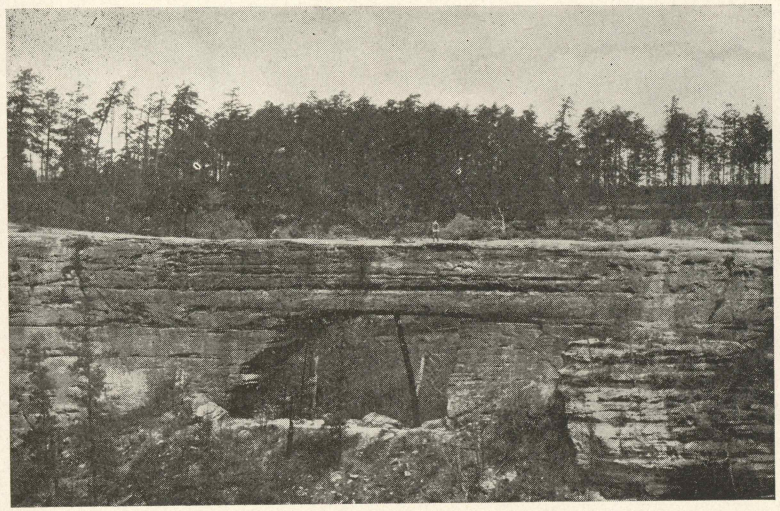
Broadly, the cave region of Kentucky includes, however, certain areas within the Bluegrass, and others, such as the Carter County caves, adjacent to the western border of the Eastern coal-field, where the Pottsville conglomerate outcrops. The caves of the Eastern and Western coal-fields are for the most part not real caves, but rock-shelters, or "rock houses," as they are commonly called, hollowed out places underneath strong and resistent ledges of Coal Measures sandstone, or conglomerate. Many well known true caves occur in the upper Mississippian limestones along the northwestern, or upturned, edge of Pine Mountain.

There are no caves in Kentucky west of the lower Cumberland River. The Kentucky caves exhibit one of the few instances where the natural fauna and flora are still to be found. Original, aquatic biologic conditions of western Kentucky, adjoining the Mississippi River, and in some portions of the Western coal-field of Kentucky adjoining the Ohio River, simulate the original, or natural, condtions and will be found an enjoyable retreat for the nature-lover.

It is extremely unfortunate that in a state endowed by nature with so inspiring a topographical panorama, where mountain and hill land contrast so pleasingly with rolling plateau and barren, and where originally beneath magnificent, broad-leafed forests along mountain stream and meadow brook, there existed abundant and varied wild life, that such wretched physical conditions as are now only too apparent have come to exist. In settling and "improving" Kentucky, man has destroyed much that can never be replaced. Rivers which were once clear and full from headwaters to lowlands are muddy throughout the greater part of the year. During periods of flood their streams and many of their larger tributaries have become a growing menace to all populations along the lower courses. Countless thousands of smaller streams are now, during the summer months, intermittent. Tens of thousands of acres in Kentucky have been cleared and cropped for corn until their productivity has reached the zero point of practical value. Many such areas through the years have become badly washed and gullied by erosion. Within the last decade a growing tendency to throw such tracts back to



nature has become apparent. The process of healing the appearance of such areas by new forest growth is rapid and sure enough where the tract is not grazed, but the time period involved in the production of new soils for these areas is very great indeed.



NATURAL BRIDGE, WOLFE COUNTY

Though much has been lost through mismanagement and irresponsible exploitation, it is not too late for Kentucky to save areas, particularly some of those which have been indicated. A Statewide movement by means of which wornout lands might be returned gradually to the natural, or semi-natural, condition would have much to recommend it from the angle of sound economics. Such a movement would, of course, properly look to the preservation of some of those recessive areas which simulate the natural condition, before they too have been robbed of their virgin beauty and charm. The value of such areas to the state may be summed up under the following heads:

(1) Scientific study along ecological lines; (2) popular recreation for urban population; (3) preservation of natural historical conditions: (4) preservation of reservoiring areas along and at the headwaters of major watersheds; and (5) fish and game preserves, and bird sanctuaries.

A state-wide movement looking towards the preservation of

natural conditions in certain areas in Kentucky for posterity can only succeed with the co-operation of the entire citizenship. Such tracts will have to be acquired by the State. At present there are no large, state-owned lands in Kentucky with the exception of a single isolated and unimproved tract of about 3400 acres on the steep side of Pine Mountain, in Harlan County. Like adjoining areas this tract unfortunately has been deforested. A popular demand for natural, or State, parks will finally come in Kentucky through education in the schools and colleges, and in the press. Some impetus to such a movement has already been given by the people of the central and eastern United States in Iowa, Illinois, Indiana, New York and New England. Systematic organization has been fostered by the National Conference on State Parks. Some scientific societies, chief among which is the Ecological Society of America [4] have also taken steps to point out the growing necessity for the preservation of natural conditions in the several Commonwealths of the United States.

Reliable information descriptive of the areas which have been indicated as still possessing a natural characteristic is meagre and widely distributed through a series of publications, chief among which are the following:

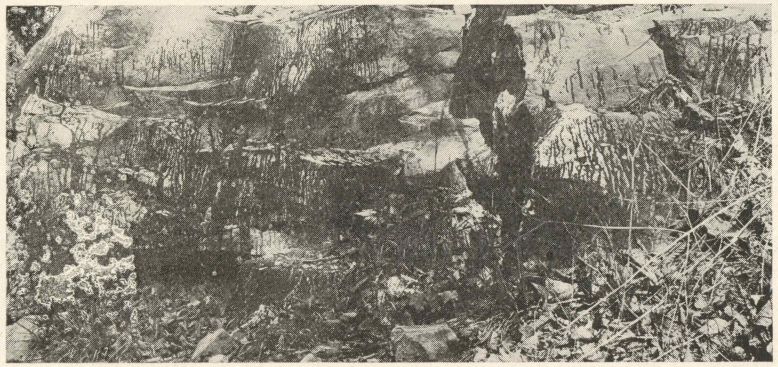
(1) Publication of the Kentucky Geological Survey, (2) the Kentucky Department of Agriculture, (3) the Kentucky Fish and Game Commission, (4) the Kentucky Agicultural Experiment Station, University of Kentucky, (5) the U. S. Department of Agriculture, (6) the U. S. Geological Survey, (7) the Filson Club, (8) the State Historical Society, and (9) the standard Kentucky histories.

[4] Preservation of Natural Conditions. Ecological Society of America; Reprint by the National Research Council, 1921, Springfield, Ill., 1922.

# VIII.

## KENTUCKY ROCK ASPHALT*

The occurrence n Kentucky of bituminous sandstones naturally impregnated with petroliferous residues has been a matter of scientific record for over seventy-five years. Dr. David Dale Owen, in executing the first Geological Survey of this State, noted them and their "tar springs" at many points. References to them are to be found in many of his reports.[1] In the work of geological explorations which followed under the direction of Nathaniel S. Shaler, and later under Robert Procter, bituminous sandstones and limestones were frequently found, analyzed and described.[2] The great commercial future of these very ex-



CHESTER ASPHALT LEACHED BY SUN'S RAYS

tensive deposits, at this time, was, however, hardly surmised, and consequently little more than passing attention was given to them.

In the report published by the Third Kentucky Geological Survey, under Prof. Charles J. Norwood, little appears concerning them; but during the Fourth Geological Survey, under the direction of Joseph B. Hoeing, they suddenly sprang into prominence and were described specifically and regionally in two sep-

* Pan-American Geologist, Vol. XLI, pp. 251-258, May, 1924.
[1] Kentucky Geol. Surv. (1), 1854-7.
[2] Ibid. (2), 1873-92.

arate reports.[3] During the progress of the Fifth Geological Survey these deposits received but casual consideration; but in the publications of the Sixth Geological Survey, they again received special and state-wide attention.[4]

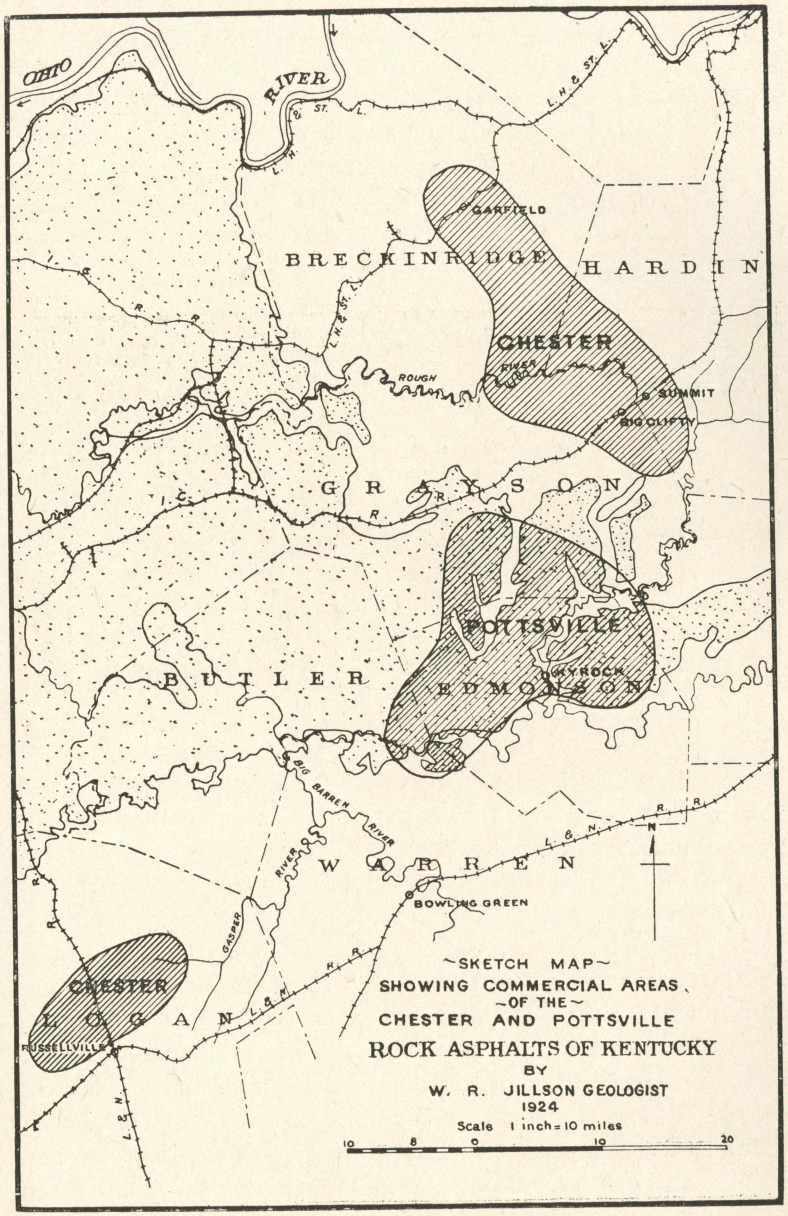
At the present time the Kentucky Geological Survey is engaged in very extensive and detailed examinations of the rock-asphalt deposits of the entire State. The reason for the present widespread interest and startling development in Kentucky rock asphalt is found in the strong upward economic trend of the market during the past five years. The future demand, backed by large road-building programs, now under way in all adjoining commonwealths, appears actually unlimited. When properly quarried, mined, milled and used in superior highway construction, Kentucky rock asphalt is by far the most attractive surfacing material yet developed. Noiseless, dustless, and almost everlasting, it finds warmhearted approval wherever introduced. As a result of its many outstanding virtues as a road-surfacing material, its market has extended itself automatically with the astonishing results, that although the number of commercial operators has now increased to four in Kentucky, each plant shipping a mill capacity, the market is greatly underproduced.

The term "Rock Asphalt," in Kentucky, has become standard with reference to bituminous sandstones sufficiently impregnated with petroliferous residues of an asphaltic nature, to exhibit upon careful analysis a total content of bitumen ranging from about five to fifteen per cent. Leaner and richer natural mixtures occur, but these are excluded in the common acceptance of the term.

Limestones impregnated with petroliferous residues also occur, notably in Nelson, Madison, Marion, Bell and some other counties, but these fall outside of the consideration. In its strict sense "Rock Asphalt" is a natural mixture of silica sand, known as the mineral aggregate, and natural residues of petroleum, that will bond as a road surfacing material and withstand long continued heavy traffic. Standard specifications 5 call for from 7 per cent. to 9 per cent. of natural bitumen, in the mineral aggregate, finely pulverized and free from lumps and foreign

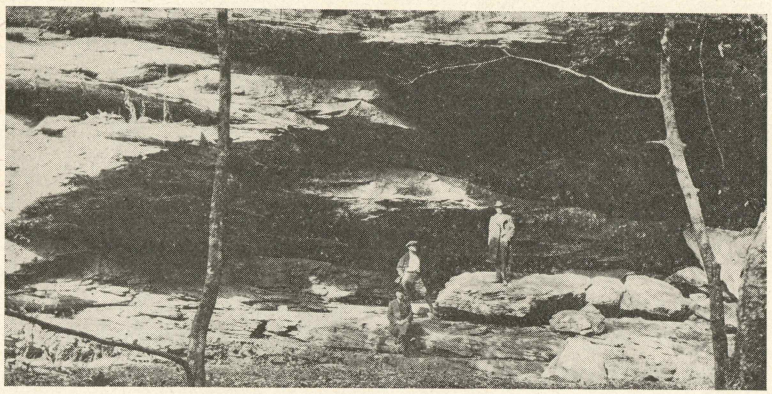
[3] Ibid. (IV), 1912-18.
[4] Ibid. (VI), Vol. II, 1921.






MAP OF ROCK ASPHALTS OF KENTUCKY

matter. The rock asphalts of Kentucky are well exemplified in type deposits ranging from 20 to 50 feet thick in western-central Kentucky, in Edmonson, Hart, Grayson, Hardin, Breckinridge, Warren, Logan and some adjacent counties. Stratigraphically these deposits fall into two groups: (1) the Chester (Upper Mississippian), and (2) the Pottsville (Lower Pennsylvanian).[5] The rock asphalts of the Chester rocks are the older and more widely distributed of the two groups and will here receive the first consideration.



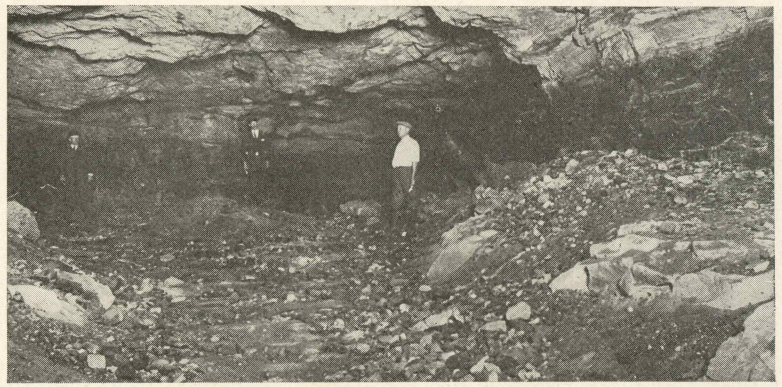
CYPRESS SANDSTONE, BIG CLIFTY CREEK

An investigation into the use of Kentucky rock asphalt as a road material indicates that it has been in use, sporadically for upwards of 25 to 35 years. The old Federal Asphalt Company, about 1900, operated mines and quarries in the Cypress formation, an asphalt-impregnated sandstone of the Chester near Big Clifty, Grayson County. A very satisfactory product was made, and many city streets and park-ways in Ohio, Kentucky, Pennsylvania and New York were laid with the material. Illustrations of this old mining operation are given herewith. Other operations less extensive, and one at least much larger, that of the old Wadsworth Stone and Paving Company on Green River, occur in Hardin, Grayson, Breckinridge, Logan, Warren, and Edmonson counties. Chester and Pottsville rock asphalt taken from various openings thus located during the past twenty years,

[5] Standard Specifications for State Road and Bridge Construction: Missouri State Highway Comm., pp. 84-89, Jefferson City, 1922.



has been shipped to points in New York, Pennsylvania, Ohio, Indiana, Missouri, Tennessee and Kentucky, and has been used for streets, highways and sidewalks with complete satisfaction in all cases where it was laid on a sound base. Though it is difficult to trace the movements of this rock asphalt, it is known that all



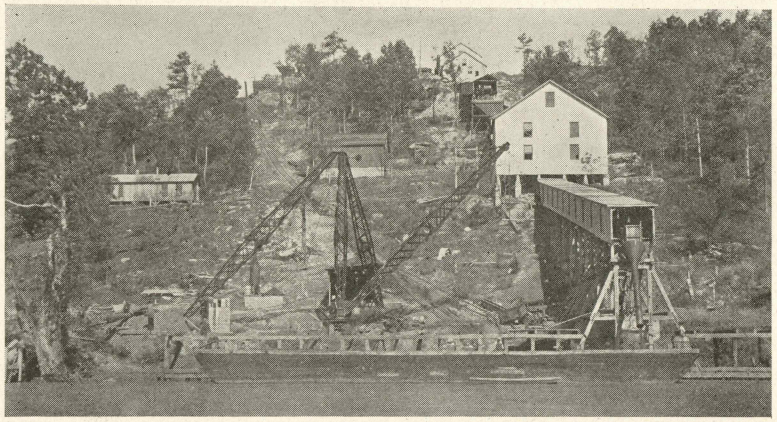
INTERIOR OF OLD FEDERAL ASPHALT MINE

of the material thus used was not shipped from any particular section, though it is probable that the major portion of it was produced from the Big Clifty (Chester sandstone), in eastern Grayson County.

The Chester formation in Kentucky exhibits two bituminous sandstones. These are in ascending order the Cypress sandstone, 70 to 80 feet in thickness, and the Tar Springs sandstone, 40 to 50 feet in thickness. The Tar Springs sandstone is not regarded as of commercial importance as a rock asphalt source, due to the fact that its bituminous content is high in volatiles and relatively low in asphalt base. Its occurrence as a thinner member and higher in the Chester succession is resultant in a smaller areal outcrop than in the case of the Cypress sandstone, which is nearly twice as thick and which occurs at some little distance below it. For this reason, although a number of asphalt outcrops of the Tar Springs sandstone is known to occur, particularly in northwestern Breckinridge County, this stratigraphical member will not receive further consideration.

The Cypress sandstone, broadly outcropping from the Ohio

River through the middle portion of Breckinridge County, northern and eastern Grayson County, southwestern Hardin County, Hart County, southern Edmonson, northern Warren, southern Butler and northern Logan County, and on to the west, is the largest bituminous sandstone in outcrop in Kentucky. Although highly petroliferous at a number of points, particularly in Breckinridge, Grayson, Hardin, Warren and Logan counties, it is not continuously so, and there are broad areas where it is absolutely barren of petroliferous matter.



ROCK ASPHALT MILL ON GREEN RIVER

In Breckinridge County, in and about Garfield, on the L. H. & St. L. Railroad, are extensive deposits of possibly commercial importance. The same is true for northeastern Grayson County, in the vicinity of Big Clifty and Grayson Springs Station. The Continental Rock Asphalt Company, with a milling capacity of 500 tons a day, is now operating at Big Clifty and a few miles to the northeast on the Illinois Central Railroad at Summit, in southwestern Hardin County, the Ohio Valley Rock Asphalt Company is operating with a capacity of 1,000 tons a day. Plans now under way contemplate commercial operations at Garfield, in Breckinridge County, and near Russellville, in Logan County. Each of these plants will operate rock asphalt coming from the Cypress, or Big Clifty, sandstone of the Chester section.

Since the market is apparently destined to receive a very large amount of rock asphalt from the Chester horizon during the next few years, it is worth while to make comparisons of this



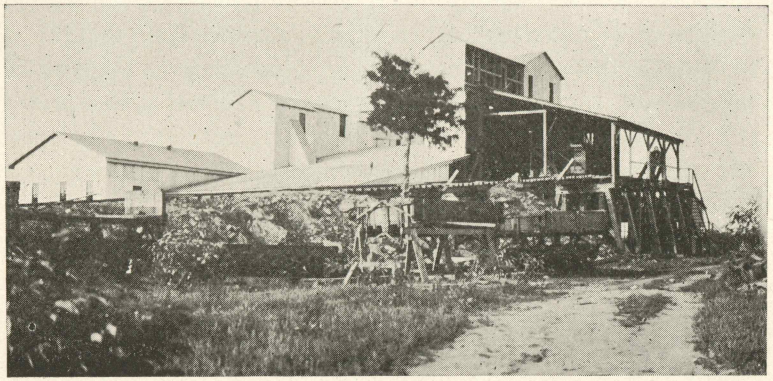
rock asphalt with that produced from deposits of the Pottsville sandstone, in Edmonson and Grayson counties. The following table showing such comparison of typical analyses brings out concretely the fact that the rock asphalts produced from the Cypress sandstone have a somewhat finer mineral aggregate, but on the other hand a somewhat higher bituminous content. This is as it should be, since a finer mineral aggregate may be interpreted to constitute a somewhat larger material surface to be covered with bituminous matter. Each of the representative samples here referenced was collected by the writer. Analysis was made by the State Chemist, Dr. A. M. Peter.

COMPARISON OF KENTUCKY ROCK ASPHALTS

| Chester (Big Clifty) Sandstone Hardin, Grayson, and Logan Counties | Pottsville Conglomerate Edmonson County |
|---|---|
| Lab. No. 4146—Bit. Cont. 9.96% | Lab. No. 4102—Bit. Cont. 8.98% |
| Lab. No. 4132—Bit. Cont. 8.28% | Lab. No. 4112—Bit. Cont. 6.83% |
| Lab. No. 4036—Bit. Cont. 7.61% | Lab. No. 4113—Bit. Cont. 8.49% |
| Lab. No. 4068—Bit. Cont. 7.38% | Lab. No. 3968—Bit. Cont. 8.00% |
| Lab. No. 4150—Bit. Cont. 6.82% | Lab. No. 3890—Bit. Cont. 7.35% |
| Lab. No. 4149—Bit. Cont. 9.14% | Lab. No. 3968—Bit. Cont. 8.00% |
| Average total bituminous content of Chester Asphalts 8.19+% | |
| Average total bituminous content of Pottsville Asphalt 7.94+% | |
| .25+% | |

The slightly larger bituminous content of rock asphalt produced from the Cypress sandstone, may not be taken to mean that roads produced from this material will slip, or slide, or corrugate, or in any way be defective, except where standard specifications for the laying of this rock asphalt have not been followed. Oppositely to such a contention a slight increase of ½% to 1% above the general grading of 7½% bituminous matter is, and particularly in this rock asphalt, a positive advantage, since it tends to bind the material aggregate much closer and render it more impenetrable to the eroding influence of wind and water. The writer has personally inspected a number of roads and highways surfaced during a period of years with rock asphalt produced from Cypress sandstone and has yet to know the first instance of dissatisfaction in the service rendered by the material, particularly with reference to the bituminous content where standard specifications were followed. Where this rock-asphalt

shows a bituminous content of from 7 to 9% there can be no doubt but what it is the equal of any other Kentucky-produced rock asphalt, including that of the Pottsville conglomerate, which will now be discussed.

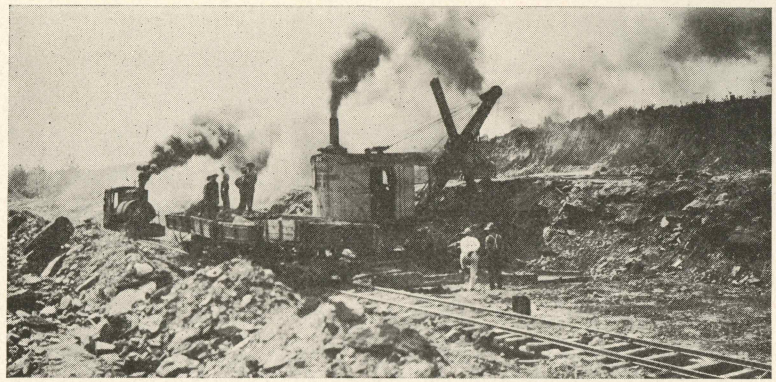


ROCK ASPHALT MILL, SUMMIT

In northern Edmonson, southern Grayson and western Hart counties, large deposits of rock asphalt occur as the Pottsville rocks (Pennsylvanian). In comparison to their extent these deposits are at present but slightly operated. The largest operation, owned by the Kentucky Rock Asphalt Company, is situated on the Nolin River, six miles above its juncture with Green River, in central Edmonson County, at Kyrock post-office. In western Edmonson County, on the lower waters of Bear Creek, near the Butler County line, and near Green River, the Natural Rock Asphalt Company has an extensive operation. Rock asphalts here operated are bituminous sandstones in the conglomerate portion of the Pottsville formation. These sandstones are somewhat coarse and more irregular than those of the Chester rock asphalts. Pebbles of the size of a pea, or somewhat larger, are not infrequently found. The mineral aggregate is roughly irregular and angular, and the bituminous content of operated lenses stands well within the standard specifications of 7 to 9 per cent. of bituminous matter. In this field there are a number of outcrops which are somewhat richer in bituminous matter, running up to 10, 12 and 14 per cent., and in these localities natural "tar springs" are of common occurrence.



Edmonson County rock sphalt, as produced by the Kentucky Rock Asphalt Company from 1918 to date, has become standardized as a road material in this and adjoining states, and well deserves the recognition given it by road enthusiasts everywhere. A large field here awaits the projection of new rail and river transportation which all signs indicate will be brought about within the next few years. Plans are now already under way for the operation of a large boundary by the Silica Asphalt Company, southeast of Leitchfield, on the waters of Conoloway and Bear creeks. Other operations are contemplated near Black Rock post-office, a few miles southwest of Leitchfield.



ROCK ASPHALT QUARRY AT SUMMIT

The uniformity of the product now produced in Edmonson County by the Kentucky Rock Asphalt Company and the Natural Rock Asphalt Company; in Hardin County by the Ohio Valley Rock Asphalt Company, and in Grayson County by the Continental Rock Asphalt Company, leads to the conclusion that this high grade road-surfacing material will find a continually broadening market, and one in which satisfaction will contnue to develop an increasing demand. The possibilities of rock asphalt development in Kentucky from a quantitative standpoint are almost unlimited, and with the qualitative requirements of standard specifications satisfactorily met by the rock asphalts of both the Pottsville and Chester formations, an interesting prospect for the development of this great mineral resource of Kentucky is assured.

# IX.

## OUTLOOK FOR MINERAL DEVELOPMENT IN KENTUCKY*

As detailed geological work has progressed in Kentucky during the last decade, it has become more and more apparent that the State's mineral resources are but slightly developed. This is true, though the last ten years have seen more operations started in Kentucky than has any similar time in the state's history. Statements relative to the natural wealth of Kentucky have, however, become axiomatic to such an extent as to have lost their force, and consequently any such discussion calls forth much less in the way of enthusiasm than it merits.

Newly coined words and phrases are the precursors of fundamental changes, economic and social. Rarely ever are great advances indicated by worn-out similes or descriptions. The greatest obstacle in the development of Kentucky today is not the lack of actual extension of all mineral operations on a grand scale, but rather a lack of serious thinking and a desire to extend these mineral operations. Where there is a will there is a way. If the minds of the people of Kentucky were seriously attuned to the possibilities of mineral development in this state, that development would surely follow in course.

### Base Mapping a Neccessity

Among the several obstacles to the development of Kentucky, there are a number which are actual and concrete. Some of these, peculiar to wide areas, are found by the mineral operators to be a brake upon development. Foremost in this class is the lack of a complete topographic base map for this state. On July 1, 1923, Kentucky, with an area of 40,598 square miles, had mapped 19,893 square miles, a considerable portion of which was on a small scale, leaving unmapped 20,705 square miles.

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* Manufacturerers Record (The South's Development), Vol. LXXXVI, No. 24, Part II, Dec. 11, 1924.

### Rich Resources Hidden

The vastness of the territory unmapped in Kentucky is best conveyed to the lay mind by saying that after one leaves Grahn Station in central Carter County there are no topographic base maps until Lexington is reached. From Georgetown northward to Covington there is no topographic base map. From Shepherdsville southeastward to Somerset, south to Tompkinsville and west to Hawesville there are no topographic base maps, and from Bowling Green westward to the Mississippi, and from Murray north to Smithland there are no standard maps. This broad territory thus roughly described and constituting the heart of Kentucky is richly underlain with asphalt, fluorspar, clays, coal, oil, gas and other minerals, all of which are unmapped in any accurate manner.

Fortunately for this large unmapped territory, the Kentucky Geological Survey has been able to execute a number of rapidly surveyed reconnaissance maps which enable those who may be interested in this territory to find their way through it, but these maps are not accurate enough to serve as a base for detailed geological, soil, highway or other investigations.

A serious obstruction to the advancement of mineral development in Kentucky is found in the lack of appreciation at home of the work which the Kentucky Geological Survey has done in the past, and may do in the future if properly financed, for the people of the state. It is not an unkind thing to say that this popular attitude is due to a lack of information on the part of the general public, and semi-hostile, depreciatory attitude on the part of former state officers who for decades have closely circumscribed the field activities of the Kentucky Geological Survey by reducing its finances to a mere pittance. The poverty of the State Geological Survey has not infrequently been recognized in the past, and many promises have been made as to its financial reorganization, but this worthy idea has never been accomplished, though thousands of well-informed citizens wish the department well.

### Mineral Interests Indifferent

The fact that remains and stands out now most prominently is that the Kentucky Geological Survey does not have the organ-



ized support of the mineral interests of the state. It also lacks a full recognition and lively interest on the part of those who control the destinies of the state.

Some one has said that fear is a normal part of life. Every individual, every corporation and every organization has it in one form or another, and the great mineral groups of Kentucky, strong as they may be in numbers, and compact as they may be in organization, are afraid to support the Kentucky Geological Survey because of what they plead might be asked of them in return. It does not help the matter any to say that these great organizations are afraid of hobgoblins. Though this fear is founded on a great fallacy, it is one of the greatest obstacles to the development of the mineral interests in Kentucky.

If the coal organizations, the oil organizations, the flourspar, asphalt and clay operators and the various quarry men of this state would band together and demand that the mineral resources of the state be base mapped, and that adequate geology be laid down on these maps forthwith it could easily be done, and nothing could be made to stand in its way.

### Total Mineral Production

During the three years 1918, 1919, and 1920 crude production of coal, petroleum, and fluorspar in Kentucky was valued at $401,251,701. The total mineral production for these same years is estimated to have been not less than $450,000,000, probably more. The world demand for certain crude minerals, such as coal, petroleum, rock asphalt, and fluorspar, is increasing rapidly year by year, and the production of these minerals in this state can be made to increase in proportion, since they are produced here in superior quality. Lack of initiative holds them to comparatively low volume, however, while economics makes its appeal to home-folks more or less in vain. In the year 1923 Kentucky produced 41,000,000 tons of coal, valued at $112,000,000 and 8,069,000 barrels of oil, valued at $15,169,000. Its possibilities were certainly greatly in excess of mere figures.

The aggravating problem of farm-land taxation which confronts Kentucky could be most readily and soundly solved by a development of the mineral and natural resources of Kentucky.

Circling the bluegrass region of Kentucky are twenty-five so called pauper counties. Practically all of these counties are unmapped, although they contain vast mineral reserves of one kind or another. These pauper counties are a great burden upon the self-provident, agricultural and mineral counties of eastern, central and western Kentucky. The only sound way to lighten the tax burden af the central and western Kentucky farmer is to topographically base-map and develop the mineral resources of this great incompleted area and make it self-sustaining. This can be done and by the expenditure of a much more insignificant sum than that which is now being spent to sustain them in poverty from year to year.

### Asphalt and Fire-Clay Fields

The great rock asphalt field of Kentucky underlies parts of Grayson, Edmonson, Hart, Breckinridge, Warren and Logan counties. One of the greatest flint fire-clay fields and cannel-coal fields of the United States underlies Carter, Rowan, Morgan, Elliott, Greenup and Lewis counties. Mineral development and the introduction of new plants and industries, with their dependable payrolls, would provide new tax sources both for the counties and the state in all of this vast region.

The Kentucky Geological Survey by statutes is the coworker with other departmental organizations of the state. It should also be a coworker with other departmental organizations of the state. Full advantage is not now being taken of the opportunity offered to make practical use of the Kentucky Geological Survey and its publications, nor has it ever been. The pioneer of mineral development, the explorer of mineral wealth, and the adventurer among the unmarked and little known portions of the Commonwealth, the Kentucky Geological Survey has already done much to advance this Commonwealth along material lines.

### Great Development Possible

If properly financed and fostered by public opinion, this department can do more in the next few years to advance the interests of the people of Kentucky for the amount of money which may be spent upon it than any other single department of



the state government. Kentucky's resources in coal, oil, asphalt, fluorspar, building stones and what not else are vast enough to support an annual crude production value of at least $500,000,000. All of this increased mineral production would necessitate a parallel or sustaining development, consisting of new houses, stores, factories and miscellaneous industry. The day when Kentucky may present her crude mineral values in maximum denominations will continue, however, to be delayed as long as the people hold the present attitude towards the support of the Kentucky Geological Survey, the one state department which holds the key to the mineral wealth of the Commonwealth.

# X.

## AMERICAN KARST COUNTRY.*

One of the unique and most interesting physiographic regions in our country is that which has, within recent years, come to be designated as the "Karst" region of Kentucky. Little is known concerning the karst topography in this state, the literature offering nothing more than casual references. Caves and subterranean streams have been widely known, however, since the legendary Houchins drove his wounded bear into a great cavern and discovered Mammoth Cave. The first authentic record to the Mammonth Cave goes back to 1797 and is found in connection with a land description in a deed on file at Bowling Green.[1] But it is a long step from simple cave discovery to description of a region, or group of regions to be more exact, as extensive as is this.

The lack of more definite knowledge with respect to Kentucky's karst region may be properly attributed to the fact that good topographic maps to the scale 1:62,500 have not been available. Without these it has been impossible for students, and others than travelers to see the true figures of American type of karst relief. Yet, here in southern-central Kentucky, as in the classic area in southern Europe bordering the Adriatic Sea, the principal amount of drainage is subterranean. Ohio Valley Karst regions, however, lack the barrenness and desolateness so characteristic of the European type-locality. From a structural angle they are much less deformed, faults as large and extensive as those described by Suess[2] for the Mediterranean region being unknown in this part of America. The completion of a number of strategically located topographic sheets, chief among which is the Mammoth Cave Quadrangle, scale 1:62,500, contour interval 20 feet, within the last few years, however, has brought out much of the detail of both the karst and the sinkhole regions throughout the State. In general, the areas in which subterranean drainage is found chiefly are coincident

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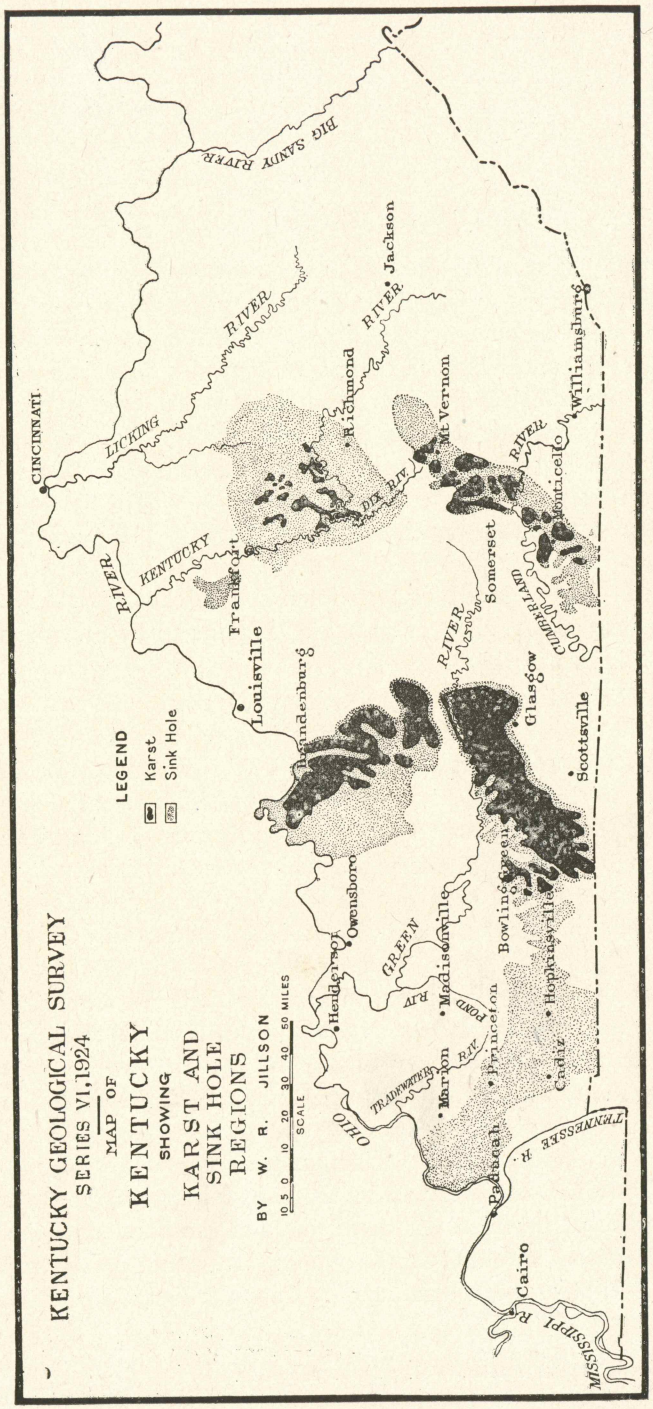
* Pan-American Geologist, Vol. XLII, pp. 37-44, Aug., 1924.
[1] Hovey's Mammoth Cave, Kentucky, p. 9, 1909.
[2] Face of the Earth, Vol. I, pp. 266, 269.

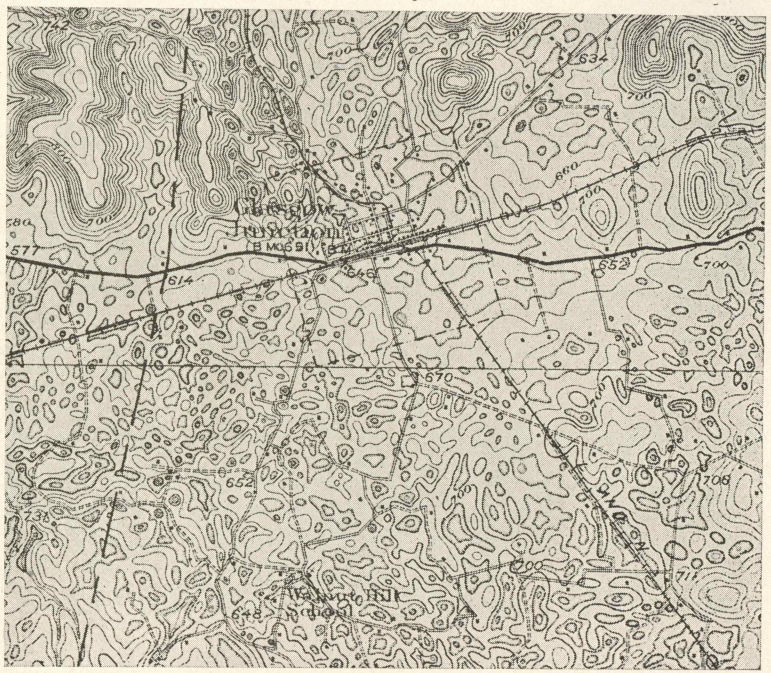



KARST AND SINK-HOLE TRACTS IN KENTUCKY



with the areal outcrop of the upper Mississippian rocks; and the middle and lower Ordovicic limestones, as known in central Kentucky.

Regionally the karst areas are separated, the chief, or typical, karst topography being found in the vicinity of the Mammoth Cave, in Edmonson County. From this locality karst and sink-hole topography extends southwestward through the

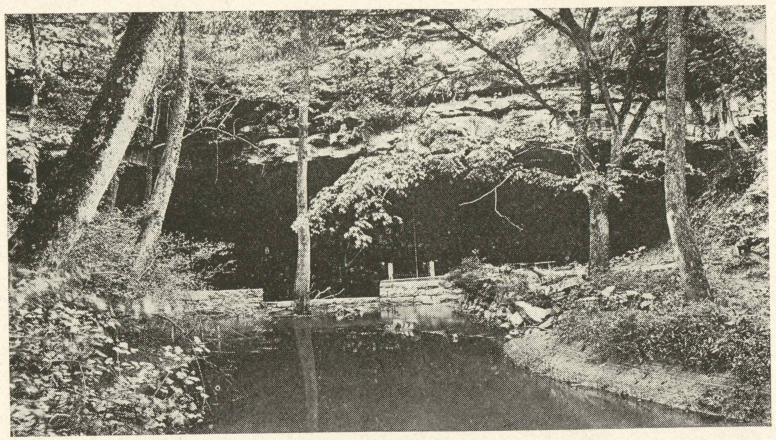



TOPOGRAPHY AROUND GLASGOW JUNCTION

Bowling Green region to the Tennessee line. This area is approximately 72 miles in length, and 12 miles in width, and comprises 850 square miles of karst topography. It is surrounded by a belt of sink-hole territory which, when totaled with the karst region, gives an area of 1,400 square miles in which the drainage is, for the most part, subterranean. Extending westward from the vicinity of Russellville and sweeping around to the northwest to the Ohio River is a broad continuous outcrop of Chester limestones, sandstones, and shales. Although the

area is widely pitted with sink-holes, only a portion of the drainage is subterranean. This broad territory is over 100 miles in length and of very irregular figure. It contains about 1,700 square miles, but is not to be regarded as a typical karst section though some very restricted portions are so.

Extending northwestward from a narrow finger of the Coal Measures, which lies north of the Green River in the vicinity of Munfordsville, is an area in which karst and sink-hole topography predominates. Karst regions here are confined principally to the ridges, or uplands, and are of irregular and discontinuous ridge-figure. The extent of the karst and sink-hole topography in this area lying between the Green River and the Ohio is about 60



"LOST RIVER" DISAPPEARING NEAR BOWLING GREEN

miles in a northwest line, and 30 miles in width. The karst areas within it comprise about 350 square miles, while the total karst and sink-hole areas total 1800 square mles.

Along the southwestern border of the Eastern coal-field, from a point somewhat northeast of Mt. Vernon through Monticello to the Tennessee line, there is a strip 80 miles long and 13 miles in width of combined karst and sink-hole topography. The karst areas are small and isolated, being confined to certain restricted elevated portions adjoining the major drainage. The karst areas here will amount to 175 square miles, and the total



of the entire area of karst and sink-hole topography will equal 1050 square miles.

In central Kentucky, the Blue Grass region of the State, there is a roughly triangular area some 40 miles across which exhibits a large number of sink-holes. Within this area there are to be found some very restricted areas of high elevation adjoining lines of deeply trenched drainage that might be said to be karst in its characteristics. The total of these small isolated patches of karst topography will hardly equal 75 square miles, but the area of sink-holes which encloses it is of broad extent, and covers at least 1600 square miles. In summation, then, a table of karst and sink-hole areas in Kentucky is as follows:

KARST TOPOGRAPHY

| | |
|---|---|
| Mammoth Cave, southwestward | 850 Sq. miles |
| Munfordsville, northwestward | 350 Sq. miles |
| Mt. Vernon to Monticello | 175 Sq. miles |
| Central Kentucky | 75 Sq. miles |
| Total | 1450 Sq. miles |

SINK-HOLE TOPOGRAPHY

| | |
|---|---|
| Western Kentucky, Mammoth Cave to Tennessee Line | 1400 Sq. miles |
| Russellville to Ohio River | 1700 Sq. miles |
| Munfordsville to Hopkinsville to Brandenburg | 1800 Sq. miles |
| Eastern Border of Western coal-field, Mt. Vernon to Monticello | 1050 Sq. miles |
| Central Kentucky (Ordovicic) | 1600 Sq. miles |
| Total | 7550 Sq. miles |

A division of the above figures on a stratigraphic basis shows that the Chester outcrop (Early Carbonic age), with a pitted area of nearly 6000 square miles, is by far the broadest sink-hole region of the State. The reason for the broader extent of karst and sink-hole topography within the areas of Chester outcrop is seen to be not so much in the wide areal distribution of this group of limestones as in their relatively higher purity. The central Kentucky limestones of Ordovicic age are excellently located for the development of subterranean drainage because of their elevated position. The highest altitude in the central Blue Grass district (1071 feet) is found on a ridge slightly to the northeast

of Nicholasville, in Jessamine County. The elevation of the Kentucky River which is deeply intrenched in this section is about 525 feet above sea-level. The difference of elevation, 350 to 550 feet, affords an excellent opportunity for the reduction of soluble materials and the consequent development of sub-surface channels of drainage.

OPEN SINK-HOLE NEAR DRIPPING SPRINGS ESCARPMENT

In the Mammoth Cave region, of western Kentucky, where the Chester rocks are in outcrop, ridge elevations range generally from 700 to 800 feet. The Green River, which is locked, is about 450 feet above sea-level. Thus the maximum relief in this type karst region of Kentucky is 100 feet to 150 feet less than that of the Blue Grass region. In contrast, however, the Mammoth cave limestone is very much purer than the Ordovicic limestone, and some members of the Chester series, particularly the Gasper limestone, frequently show in analysis as high as 97 and 98 per cent. of calcium carbonate. The thickness of the Mammoth Cave limestone, upwards of 600 feet, is also impressive in this region. As the Green River has lowered its bed through these great calcareous units—Gasper, Ste. Genevieve, and St. Louis limestones—unlimited opportunity has been afforded for the development of subterranean channels at various levels. These subterranean channels to-day are fed through almost countless sinkholes at the surface. Connecting with one another at various depths they pass on as labyrinthine, flowing caves, and finally join the Green River in its gorge as underground creeks



frequently of considerable size. Such streams are Echo River and the River Styx in Mammoth Cave.

The extent of the rugged karst characteristics of this section is apparent to even the most casual observer in the field. A glance at the topographic maps now available for this part of the State reveals the extended nature of this kind of physiographic

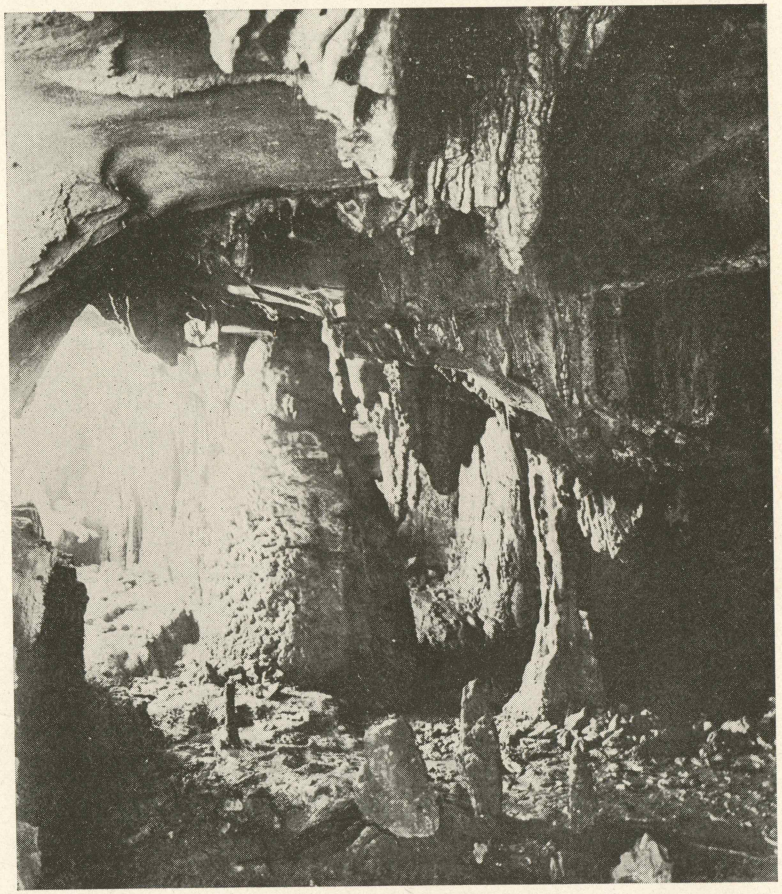
MAMMOTH CAVE REGION

feature. The exact number of sink-holes in the Mammoth Cave quadrangle, which is the type karst region of Kentucky, has been computed to be 2833, and it has been estimated [3] that in the entire Chester outcrop of the Mississippian plateau in Kentucky there are between 60,000 and 70,000 sink-holes, varying in size and description. Besides the Mammoth Cave, which enjoys a world-wide reputation there are literally hundreds of caves and caverns large and small in this karst region. Among the best known are the following: 1. Great Onyx Cave; 2. Colossal Cavern; 3. Hidden River Cave; 4. Horse Cave; 5. Crystal Cave; 6.

[3] Trans. Kentucky Acad. Sci., Vol. I, pp. 143-144, Lexington, 1924.

New Entrance to Mammoth Cave; 7. Ganter Cave; 8. Dorsey Cave; 9. Salts Cave; 10. White Cave; 11. Dixon Cave; 12. Proctor Cave; 13. Long Avenue Cave; 14. Preston Cave; 15 Highland Cave; 16. Indian Cave; 17. Parker Cave; 18. Doyle Cave; 19. Cave of Hundred Domes; 20. Mammoth Onyx Cave; 21. Diamond Cave; and 22. Cedar Sink Cave.

The Brownsville quadrangle, adjoining Mammoth Cave on the west, shows the largest mapped sink-hole in Kentucky. It is located just south of the Dripping Springs escarpment and between Girkin and Tuckertown. This great karst depression has

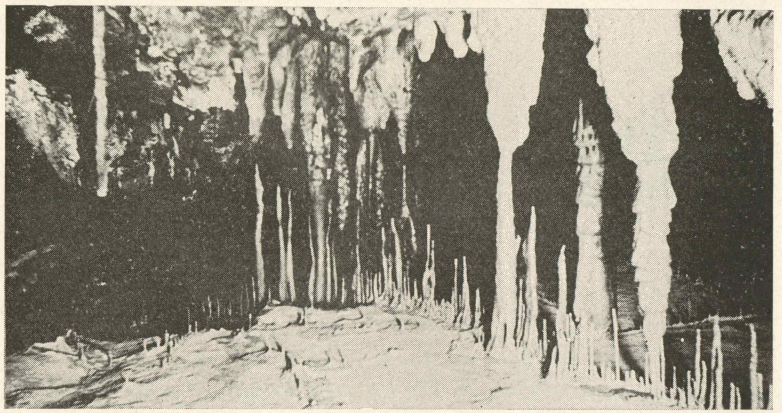


"ONYX CHAMBER" GREAT CRYSTAL CAVE



an area of nearly 5 square miles, or 3114 acres. In the vicinity of Mammoth Cave, and slightly to the southwest of the cave proper, there are a number of collapsed caverns which contain large sink-holes. Had it not been for the fact that these caverns, once evidently a part of the Mammoth Cave, were so close to the Green River, they would undoubtedly have been great sink-holes themselves. As it is, they show open drainage directly into the Green River in their lower courses. The detailed figure of some of these sink-holes is very interesting. The larger ones are frequently developed in doubles. Triples and quadruples are also found, though it is true, less often. The Dripping Springs escarpment is a natural boundary in the karst region. Larger, yet fewer, a total of but 783 sinks are found north of this pronounced physiographic line on the Mammoth Cave sheet. South of this escarpment there are 2050 sinks on this same quadrangle.

The broad extent and the well-developed nature of the subterranean drainage within the karst and sink-hole region of west-

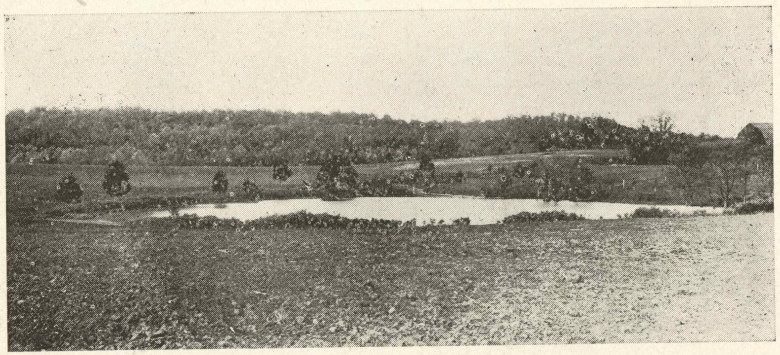


GREAT ONYX CAVE

ern Kentucky is well exemplified by the number of "lost" streams which are to be found in this region. The very extensive natural channels occurring beneath the city of Bowling Green are used for public sewage disposal with a degree of success that practically precludes the use of well water for drinking purposes in that immediate vicinity. The Brownsville quadrangle shows 1150 sink-holes, and the Bowling Green quadrangle 2563. Some 60

miles westward, between the Tradewater and the Cumberland River, the Princeton quadrangle exhibits 1429 sink-holes; and in southeastern Kentucky, the Monticello quadrangle, located on the Cumberland River and adjacent to the western outcrop of the Eastern Coal field, contains 1096, giving a total of almost 10,000 sink-holes in the topographically mapped areas of the Chester outcrop in Kentucky.

The actual extent of the sink-hole area in the central part of Kentucky (Ordovicic limestones) is unknown, due chiefly to lack of detailed mapping. The Georgetown quadrangle shows 452 sinks, the Lockport quadrangle 213, and the Frankfort quadrangle 192; a total of 757 actually counted. Based on this data with unmapped areas proportionate, it is estimated that there are



PONDED SINK-HOLE NEAR BOWLING GREEN

about 3000 sink-holes in this region, which also exhibits a large number of "lost" streams and "big" springs. Distinguished from the Chester sinks by their smaller size and number, the Ordovicic "sinking" areas are further isolated because of their position on the top of the Lexington dome of the Cincinnati arch. A somewhat distant counterpart to this region is seen in some rather restricted portions of the "Blue Grass" region of Tennessee.

The absence of extensive caverns in the karst region extending northwestward from Munfordsville to Brandenburg, on the Ohio River, is explained by the fact that the Mammoth Cave limestone in this vicinity not only thins down considerably, but becomes somewhat more siliceous. As its purity decreases the



tendency to go into solution is reduced materially. This region might, however, have contained some extensive caverns even with the lowered purity of the Chester limestones had it been traversed by a stream of deep entrenchment.

By way of recapitulation it may be pointed out that with stratigraphic, structural, and lithological factors varying greatly throughout the limestone regions of the commonwealth, those found within the Mammoth Cave region present the triple condition necessarily coincident of very thick and very pure limestones, coupled with rather deep trenching by the Green River, thus developing ideal conditions for the production of the type karst locality of Kentucky.

# XI.

## GLACIAL PEBBLES IN EASTERN KENTUCKY*

Within the last year (1923-24) the discovery of erratic pebbles of apparent glacial origin widely distributed throughout northeastern Kentucky has provided the first concrete evidence in support of a hypothesis of Pleistocene glacial ponding in a part of Kentucky heretofore thought to be without glacial characteristic. The occurrence of old elevated stream channels along the Ohio, notably at Huntington, West Virginia; Ashland, Kentucky; Ironton, Wheelersburg and Portsmouth, Ohio, has been known for some time, having been described by Leverett[1] and Tight.[2] These abandoned channels occur at elevations ranging from 680 to 690 feet above sea level. While they contain gravels chiefly composed of quartzite and chert of stream origin, possibly more remotely glacial, they are not to be confused with the pebbles which are now being found in remote parts of eastern Kentucky at much higher elevations.

In the course of non-glacial field work geologists on the Kentucky Geological Survey, including the writer, have found 18 pebbles varying in size from a few ounces to 13 pounds, consisting principally of quartzites, but with an occasional granite, gneiss or other crystalline or metamorphic rock. These pebbles range in elevation from 720 feet on the Big Sandy River to 850 on the North Fork of the Licking River, and have been found in Lawrence, Elliott, Lewis, Morgan, Carter and Boyd counties. Field evidence indicates that similar pebbles may also be found at similar elevations in parts of Menifee, Greenup and Rowan counties, though these are not a certainty. The drainage systems involved in these discoveries include the Big Sandy River, Little Sandy River and Tygarts Creek, and the North and Elk Forks of the Licking River.

Based on evidence now in hand, which will be supplemented

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* Science, August 1, 1924, Vol. LX, No. 1544, pages 101-102. Presented before the Kentucky Academy of Science, Lexington, Ky., May 10, 1924.

[1] Monograph XLI, U. S. G. S., p. 106, 1902.

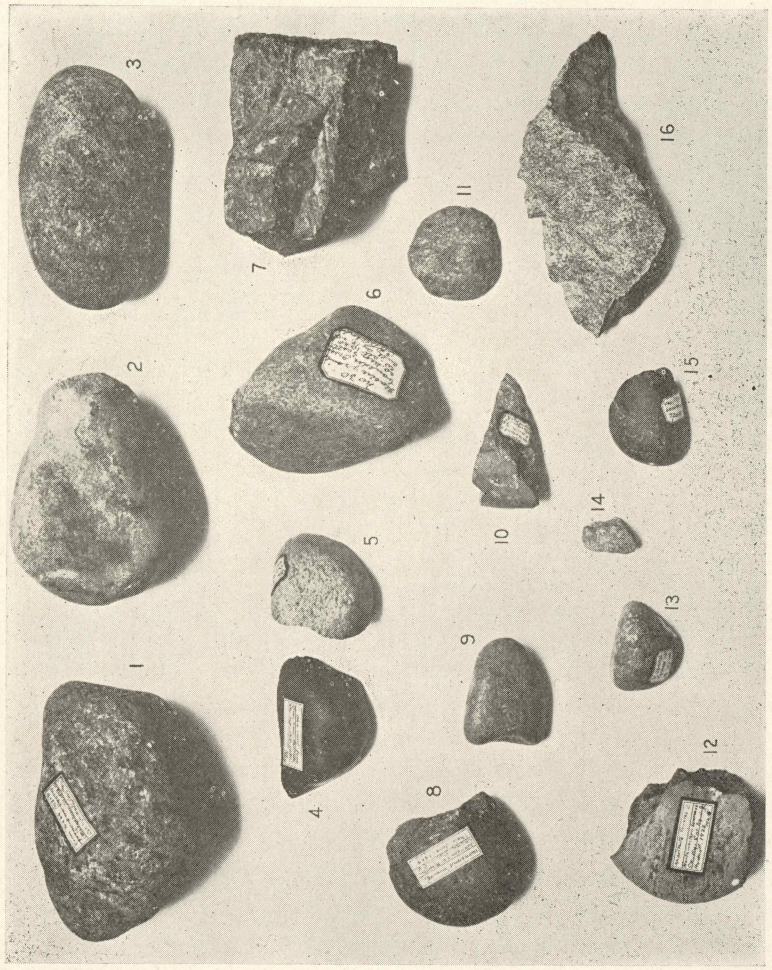
[2] Prof. Paper No. 13, U. S. G. S., Plate XV2, 1903.

this year by further investigations, the following hypothesis is advanced:

The general accordance of elevations of these pebbles coupled with certain extraneous origin and decidedly glacial characteristic suggests their invasion into Kentucky by means of floating ice. It is held that they probably represent a complex assortment derived from both river and glacial front sources during the period of readjustment of the northward flowing drainage of this portion of the Cumberland plateau, while cols were being degraded to form the present course of the Ohio River at points just above (1) Ironton, (2) Portsmouth and (3) Manchester, Ohio, and possibly just above Cincinnati. It is thought that the higher and more remote pebbles (800 to 850 feet) represent invasions by floating ice at the time of the first cutting of the Manchester col, which may have been originally about 850 or 900 feet. Ridges in the vicinity of Manchester now show elevations ranging up to 1,000 feet above sea level. Pebbles occurring in Kentucky at points near to the major drainage at elevations ranging from 720 to 750 feet are taken to represent subsequent ponding during the latter cutting of the Manchester col, and possibly those at Ironton, Portsmouth and Cincinnati. Ridge elevations at Ironton now range between 800 and 850 feet; at Portsmouth between 900 and 950 feet; and at Cincinnati( Dayton, Kentucky-Walnut Hills, Ohio) between 850 and 860 feet.

The section involved in this ponding in eastern Kentucky has not been topographically mapped except in part. Barometric elevations run throughout this section indicate that the highest ridges will range from 1,000 to 1,200 feet. At the highest level of ponding, ridge topography in this section would have appeared insular, the region resembling somewhat the Thousand Islands region of the St. Lawrence. A study of the elevations of these pebbles, their position and the gradient of some high level fluvatile gravels and terraces may possibly bring out the fact that uplift in the southwestern part of the section subsequent to the Pleistocene. The period of ponding at an elevation of 850 feet appears to have been short, as terraces apparently were not widely developed. There is no evidence now in hand to prove the extension of glacial ice lobes into this part of the state. Stratified drift is absent and ridge topography does not show a gen-






SOME KENTUCKY GLACIAL PEBBLES AND BOULDER FRAGMENTS

The districts represented by this collection are as follows: 1. Scott Co.; 2. Montgomery Co.; 3. Franklin Co.; 4. Harrison Co. 5. Carter County; 6. Scott Co.; 7. Lewis Co.; 8. Robertson Co.; 9. Pendleton Co.; 10. Lewis Co.; 11. Clark Co.; 12. Lawrence Co.; 13. Morgan Co.; 14. Lewis Co.; 15. Lawrence Co.; 16. Rowan Co., Kentucky.

eral beveling. Ponding in northeastern Kentucky at this time very possibly covered an area of about 2,000 square miles.

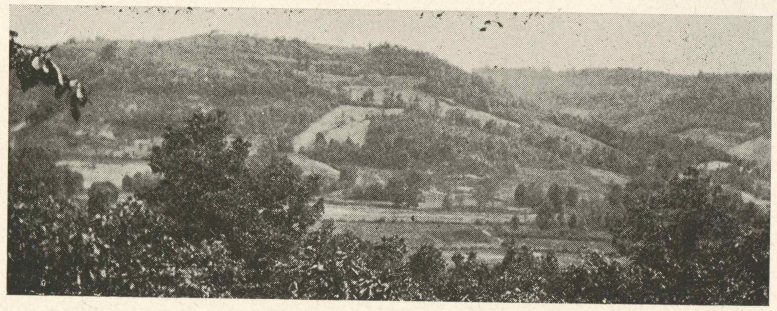
The occurrence of pebbles at high levels on that part of the drainage of the Licking River which adjoins the Little Sandy River may mean (1) that these ponded glacial waters flowed over one or more low divides in this interior part of Kentucky, and (2) that these southern cols were in direct competition for a time at least with those which were removed at such northern points as Manchester and elsewhere. To accept this theory the assumption of regional uplift in Morgan County and vicinity during and subsequent to the Pleistocene becomes a necessity. Yet this assumption would seem to be far more plausible than (1) a high damming of the Licking River and (2) glacial ice floating southeastward along the serpentine course of the Licking over 100 miles to the Elliott County line.

If the Morgan-Elliott County passes thus brought into prominence were indeed temporary debouchures for impounded glacial waters, to the superior hardness of the lower Pottsville clastics of this region and some coincident regional uplift may be ascribed the present course of the Ohio River bordering northeastern Kentucky. Had the Coal Measures sediments of Morgan and Elliott counties less competently met the erosive action of surging glacial waters the course of the then formative Ohio River would undoubtedly have been directed up the valley of the Little Sandy River and down the Licking River. Such a hypothetical change in the pattern of the Ohio River would have (1) reduced the area of Kentucky by 2,500 square miles, (2) placed Lexington, the heart of the Blue Grass Region, within 35 miles of the Ohio, and (3) profoundly altered the history and economics of the entire lower Ohio valley.

# XII.

## GLACIATION IN EASTERN KENTUCKY*

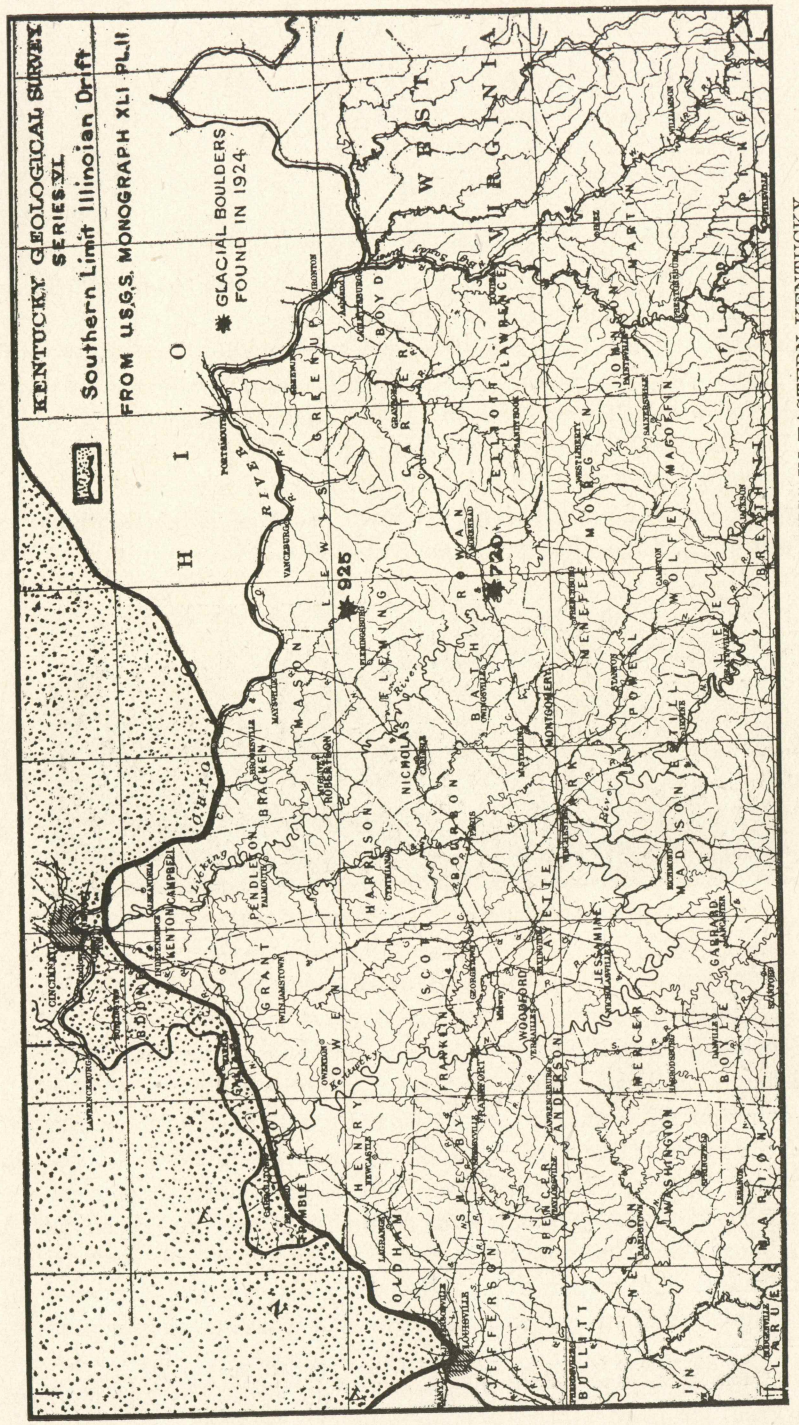
For twenty years or more geologists have held northeastern Kentucky to be unglaciated. The line of the furthest advance to the south of the Illinoian drift has been carefully traced by a number of special workers in this particular field, and has been shown to coincide generally with the course of the Ohio River from Louisville, to a point slightly east of Augusta, Kentucky. Overlaps into Kentucky have been mapped in a reconnaissance way,[1] and are known to have extended from the vicinity of Bedford, in Trimble County, through Carrollton, Warsaw, Burling-



TOPOGRAPHY IN VICINITY OF THE EPWORTH BOULDER

ton and Covington, and possibly at some few points southeast of Alexandria. Leaving the north shore of the Ohio River east of Brooksville the Illinoian drift is sketched to pass northeastward through Chillicothe, Ohio, to a point slightly northwest of New Lexington, Ohio, and thence northward parallel and slightly west of the main drainage of the Muskingum River to a point about midway between Mansfield and Millersburg, Ohio. American text-books on geology, as well as a number of accepted technical publications, in discussing the action of Pleistocene ice-sheets in the middle and upper Ohio Valley, have mapped and discussed northeastern Kentucky and southern Ohio from Manchester east-

* Pan-American Geologist, Vol. XLII, pp. 125-132, Sept., 1924.
[1] Mon. U. S. Geol. Surv., Vol. XLI, plate ii, 1902.




ILLINOIAN GLACIAL BOUNDARY AND LOCATION OF ERRATICS IN EASTERN KENTUCKY



ward through Portsmouth to Gallipolis as unglaciated territory.

During the progress of mapping the structural geology of Lawrence and Boyd counties, on the Big Sandy and Ohio Rivers in northeastern Kentucky, in the autumn of 1923, pebbles were found in both of these counties, which at first, in accordance with the accepted regional interpretation, were regarded as of stream, or channel, origin. Since the Big Sandy is not a through-flowing stream, the writer became convinced that some of these pebbles, particularly those which were of igneous and metamorphic character, might have reached their position in the field by means of ponded glacial ice, and presented this opinion.[2] Proceeding on this theory investigations by geologists on the Kentucky Geological Survey were carried out over a broad territory in the eastern part of the state, coincident with further detailed structural mapping. The first indisputable results of these investigations were: (1) That igneous and metamorphic pebbles of certain extraneous origin were much more widely distributed in eastern Kentucky than had ever before been supposed; and (2) that the problem was an important part of the unwritten geology of the Eastern Kentucky coal-field. The occurrence of these pebbles and such generalizations as were possible up to the Spring of 1924 have already been discussed.[3] The main hypothesis then advanced must now, in the light of conclusions based on more extended field investigations and collections, be somewhat modified.

While engaged in the advancement of field investigations looking toward a solution of the problem presented by the widening area in which these pebbles were found, the writer on May 26, 1924, personally discovered in Lewis County, Kentucky, a broken metamorphic boulder, described to have been originally 8x6x4 feet, and figured to weigh in excess of 16 tons. This great erratic composed of granitic gneiss, was found on the F. M. Wagner farm at an elevation of 925 feet, A. T., on the head of the North Fork of the Licking River, 3½ miles southeast of Epworth. Its occurrence had been known locally for a number of years. Since it is by far the largest erratic now known to exist in this State, and first in point of actual discovery in the northeast-

[2] Big Sandy Valley, p. 25, Louisville, 1923.

[3] Paper presented before Kentucky Academy of Science at Lexington, Kentucky, May 10, 1924; also subsequently published in Science, Vol. LX, pp. 101-102, 1924.

ern Kentucky field, it has been named the "Epworth" boulder. Its position is well up on a rather steep, wooded hillside just below the junction line of the Chattanooga black shale and the overlying Bedford sandstone. When first seen by the writer its broken fragments lay strewn over the hillside having been blown open with dynamite twenty years previously by natives searching for rare metals. Hundreds of fragments of this extraordinary rock, varying in weight from a few ounces to several hundred pounds are to be found within a circle 150 feet in diameter. It is

SOME FRAGMENTS OF EPWORTH BOULDER

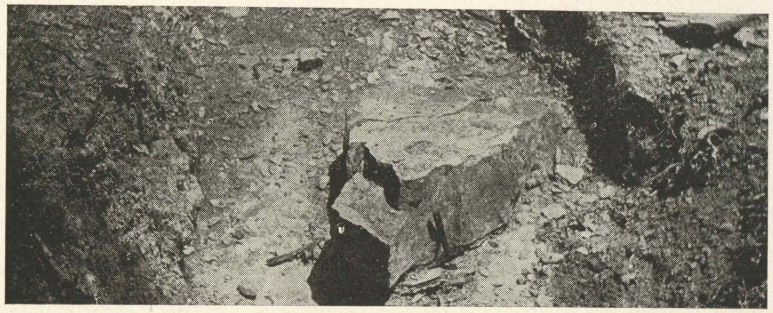
reported that a very large percentage of the fragmentary material produced by the shot has been removed during recent years by local curio hunters, and that some of the large blocks have even been removed for building construction. Strangely enough a detailed geological report [4] on Lewis and Rowan counties makes no mention of this great boulder near Epworth, nor one shortly to be described near Farmers, Kentucky.

At the point where the principal boulder was shown to have existed prior to the shot, excavations were begun in the residual soil and resulted in disclosing a large basal fragment of the boulder greatly weathered, resting directly on hard-bedded Chattanooga shale. This portion of the boulder had never before been seen. Its somewhat separated position from other large imbedded fragments leads to the conclusion that within comparatively recent times the boulder has rolled down the hillside from some higher level, perhaps that of a well defined bench on the top of the Bedford sandstone or the somewhat higher Berea sand-

[4] Kentucky Geol. Surv., Series III, Serial No. 21, Frankfort, 1912.



stone. It may have had an original elevation of 960, or possibly 1000, feet. The top of the hill which is capped with Cuyahoga sandstone is 1050 feet in height, and the valley bottom below the road is 750 feet. A thorough investigation of the locality surrounding the boulder failed to reveal the occurrence of anything even remotely similar to Glacial till, sands or gravels. Glacial beveling or sloping, of the hillsides is also absent.



EXCAVATION OF PORTION EPWORTH BOULDER

Thin sections of the Epworth boulder have been made by W. H. Tomlinson and examined petrographically by Professors W. F. Hunt and O. F. Poindexter of Ann Arbor, Michigan, whose determinations are as follows:

No. 19. Porphyritic Granite Gneiss, near Epworth, Lewis County, Kentucky. A rather dark-colored, gneissic rock, having large crystals of pink orthoclase in a coarsely crystalline groundmass of quartz, feldspar and mica.

The following minerals were identified under the microscope: Orthoclas and quartz, plagioclase (the few grains present in the section were not suitable for determining the character, however it has a low idex, and is no doubt albite or oligoclase), green biotite, muscovite, abundant apatite, zircon, hematite and limonite. Secondary minerals: Sericite, chlorite, and calcite.

Making use of information secured from Professor Poindexter of the occurrence of a peculiar boulder near Farmers, Rowan County, Kentucky, the writer on the following day, investigated this locality and found on the first left-hand branch of Main Hollow, on the property of Rowan County Freestone Co. a metamorphic boulder having measured dimensions of 2x3x6 feet, and calculated to weigh three tons. This boulder, a graph-

itic schistose quartzite, rests in the bed of the branch on the rapidly eroding Chattanooga shale at an elevation of 720 feet. It had been known locally for a number of years, and was erroneously thought by some to be a meteorite. Thin slides were made by W. H. Tomlinson, and as a result of the petrographic examinations made by Professors Hunt and Poindexter, the following very interesting determination of its lithology and metamorphic history is presented:

No. 20. Schistose quartzite. Farmers, Rowan Co., Kentucky. The specimens were taken from a boulder located on the farm of Dr. H. VanAntwerp, Farmers, Ky., at an elevation of 720 feet. The boulder is oval in shape, well rounded, and is estimated to weigh about three tons. It is light gray in color, probably due to the graphitic material present, and on a fresh fracture shows a greasy luster and resembles a mica-schist.

Veinlets of clearer quartz cut through the rock, in some cases parallel to the planes of schistosity, in other cases cutting across them. The rock may have been subjected to considerable pressure in the zone of fracture thus producing cracks which became filled with quartz deposited by the circulating waters. The microscope shows that these veinlets have also been subjected to metamorphic processes, hence it is not unlikely that the rock later passed into the zone of anamorphism where the crushing and schistosity were produced. These veinlets contain pyrite and in some cases a thin layer of limonite along the walls.

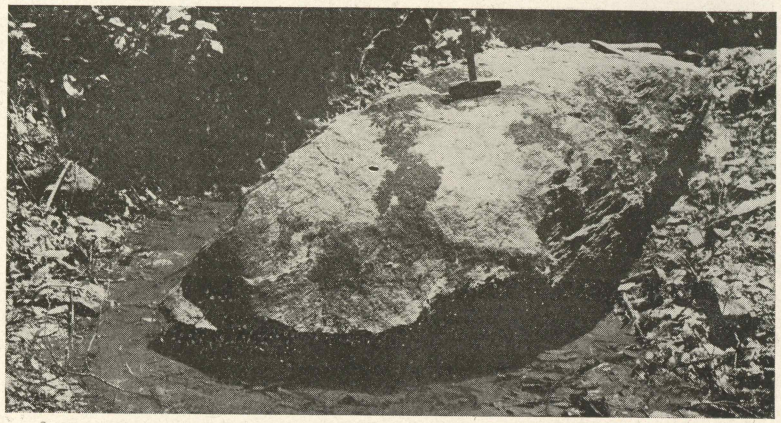
The microscope shows the rock to be free from mica with the exception of a few flakes of muscovite. It is composed almost entirely of quartz grains, which have been granulated to form smaller grains surrounding the larger ones. This is the typical "mortar" structure. In some portions, especially in the veinlets of quartz, a "mosaic" structure is characteristic, the grains interlocking with one another. A few grains of orthoclase and plagioclase are present. Numerous well developed rhombohedrons of dolomite are obviously introduced subsequent to the metamorphic processes or else they would be deformed. In some cases these crystals have been replaced by limonite.

The "Farmers Boulder" shows no appreciable amount of rock decay, but is rapidly undergoing disintegration by exfoliation, frost action and by stream corrasion. Plates from it were found in varying size, shape and description weighing from one-half pound to twenty-five pounds at various points below it in the bed of the branch imbedded among local pebbles and alluvium. It is evident that this boulder at the time of its deposition was much larger. At that time it undoubtedly occupied a



much higher position, possibly near the top of the hills (850 feet A. T.) which are capped with the Cuyahoga sandstone.

At the present time investigations looking towards the discovery of other boulders of similar size and description are being made. While it is yet too early to draw definite generalized conclusions concerning the occurrences of these boulders, the follow-



SIDE VIEW OF FARMERS BOULDER

ing points (1, 2, 3, and 4) seem established beyond a doubt, and others (5, 6, 7, and 8) are offered in advance of absolute proof simply as hypothetical suggestions.

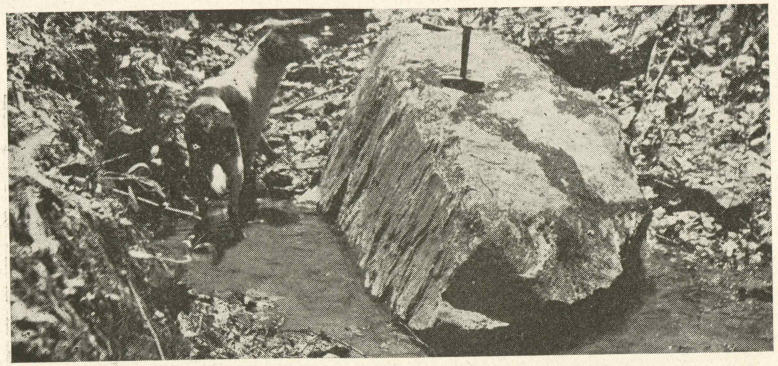
1. Each of these large metamorphic boulders differs widely from any known native rocks of Kentucky and is plainly an erratic.

2. The weight (16 tons) and altitude (925 feet A. T.) of the "Epworth" boulder, and the weight (3 tons) and topographic position of the "Farmers" boulder, preclude the possibility of their having been brought into this State by the agencies of ponded Glacial ice or fluvatile waters.

3. A Glacial ice-lobe, or sheet, extending over this portion of northeastern Kentucky covering at least 10 or 12 counties is advanced in hypothesis as the only reasonable explanation for the occurrence of these erratics.

4. The appearance of the boulders, particularly the weathered "Epworth" boulder, their elevation, the unbeveled char-

acter of the topography, and the lack of sands, gravels and tills, lead to the conclusion that these erratics were transported into Kentucky at a very early period, undoubtedly prior to the Illinoian, and possibly the Kansan stages of Pleistocene glaciation.



END VIEW OF FARMERS BOULDER

5. The hypothesis of direct age correlation with the Nebraskan drift to the Missouri Valley, or the Jerseyan drift of the Atlantic slope is tentatively advanced.

6. In event the glaciation indicated by the Epworth and Farmers boulders of eastern Kentucky cannot be correlated with either the Nebraskan, or the Jerseyan tills, it may prove to be older and more extensive southward than either. Such an hypothesis, if later substantiated, would logically lengthen the Pleistocene epoch backwards and give a better relationship between the time element of this interval and the large amount of drainage modification and deep entrenchment found in the Ohio Valley.

7. Some close correlations may also exist between these Kentucky erratics and certain Glacial boulders found by Leverett south of the Illinoian boundary in Girardeau County, Missouri (North Lat. 37° 5′) during 1923.[5]

8. In case the northeastern Kentucky and the southeastern Missouri boulders are eventually shown to belong to the same very early Pleistocene stage of all that broad territory stretching between Farmers, Kentucky, and Cape Girardeau, Missouri, becomes well within the possible limits of this early ice-sheet.

[5] Bull. Geol. Soc. America, Vol. XXXV, p. 69, 1924.



The central Blue Grass district of Kentucky in which two small Canadian granite pebbles have been found (Robertson and Clark counties) may very possibly have been ice-covered at this time. The apparent (though at present unproven) absence of similar Glacial material in central-western Kentucky may be accounted for by originally high topographical conditions further north in Ohio, Indiana, and Michigan. Mr. Frank Leverett who is now engaged in Pleistocene studies in Kentucky for the Kentucky Geological Survey holds it entirely probable that protrusions of ice would have been induced by the low-lying basins of Lake

EXCAVATION OF EPWORTH BOULDER

Michigan on the west and Lakes Huron and Erie on the east, and that the intervening prominent Michigan peninsula would have developed a recess in the southern boundary as it is likely to have impeded the movement of the ice-sheet. That early Pleistocene ice actually passed from the eastern end of the Superior basin through the Huron basin and the lowland bordering the western part of Lake Erie into the Scioto basin is known from numerous finds of Lake superior copper in the Scioto River basin, as is noted by Salisbury.[6]

[6] Trans. Wisconsin Acad. Sci., Vol. VI, pp. 42-54, 1886.

# XIII.

## EARLY GLACIATION IN KENTUCKY*

Within the past year two papers have discussed the probability of an early Glacial advance into Kentucky, covering areas heretofore regarded as unglaciated. The first of these papers[1] on "Glacial Pebbles in Eastern Kentucky" described the discovery made previous to May 10, 1924, of erratic igneous and metamorphic pebbles apparently of Glacial origin which were distributed throughout a portion of northeastern Kentucky, and called attention to the fact that this field-evidence strongly supported the idea of Pleistocene glacial ponding in a part of Kentucky regarded as lying south of the furthest southern advance of the glacier. These pebbles, it was pointed out, ranged in elevation from 720 feet on the Big Sandy River to 850 feet on the North Fork of the Licking River, and were found in Lawrence, Elliott, Lewis, Morgan, Carter, and Boyd counties. It was suggested at the time that similar pebbles might also be found in the adjoining counties of Greenup and Rowan which had at that time not been closely studied in the field.

In furtherance of the field investigations suggested by the occurrence of pebbles in northeastern Kentucky the writer independently discovered on May 26, 1924, a large, broken, metamorphic boulder, estimated to have weighed originally about 16 tons, in western Lewis County on the F. M. Wagner farm, at an elevation of 925 feet. A petrographic examination of this boulder indicated that it was porphyritic granite-gneiss. On the following day the writer found another metamorphic boulder having measured dimensions of 2x3x6 feet in southwestern Rowan County, near Farmers Station, at an elevation of 720 feet. This rock was determined by petrographic methods to be schistose quartzite of a rather unusual lithological character.

As a sequel to the discovery of these two large and undoubtedly glacial boulders the second paper on "Glaciation in

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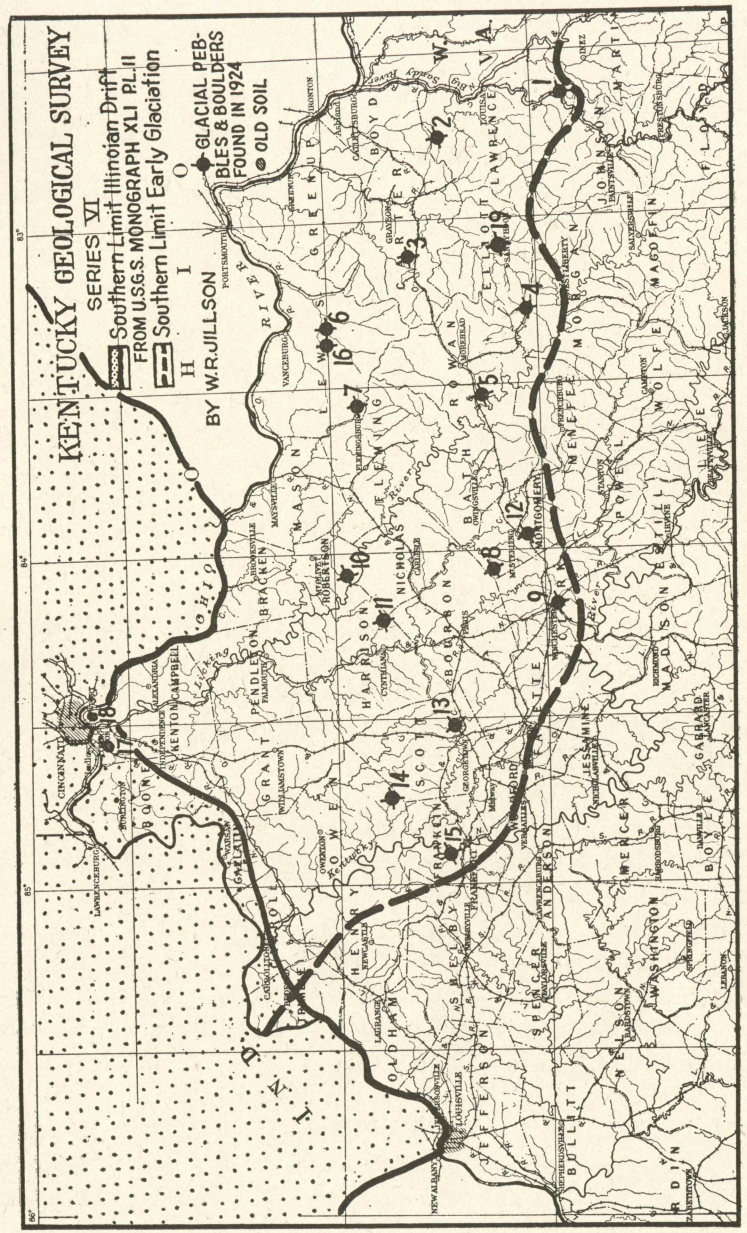
* Pan-American Geologist, Vol. XLIV, pp. 17-20, Aug., 1925. Paper read before the Kentucky Academy of Sciences, Lexington Meeting, May 15, 1925.

[1] Science, N. S., Vol. LX, No. 1544, pp. 101-2, 1924.






Eastern Kentucky'' was presented.[2] In it a new suggestion of actual pre-Illinoian glaciation in northeastern Kentucky was offered as a substitute for the earlier hypothesis which had indicated ponding. A correlation with the Nebraskan drift of the Missouri Valley, or possibly the old Jerseyan drift of the Atlantic slope, was advanced. It was also suggested that some rather close correlation might exist between these large Kentucky erratics and certain boulders found by Prof. Frank Leverett, in 1923, south of the Illinoisan till in Girardeau County, Missouri. This paper which was presented by Professor Leverett for the writer before the Geological Section of the British Association for the Advancement of Science, at Toronto, Canada, August 11, 1924, suggested in summary that it might eventually be found that all of the northern Blue Grass region of Kentucky, as well as a part of the northern portion of eastern Kentucky had been glaciated.

During the summer of 1924 the writer and his assistants on the Kentucky Geological Survey continued, in the course of other field investigations, to search for Glacial pebbles and boulders throughout the central, northern, and northwestern portions of the state. The results of this casual investigation indicate the positive occurrence of Glacial pebbles of igneous and metamorphic character, and of Canadian origin, in Robertson, Harrison, Montgomery, Clark, Scott, Franklin, and Owen counties, an area roughly coincident with that portion of the Blue Grass region of Kentucky, north of the Kentucky River. A small overlap occurs in Franklin County. These pebbles, all of hand-specimen size, range in weight from a few ounces to three pounds. They were found at various points considerably removed from highways, or railways, or human habitation. Lithologically they consist of granites, gneisses, and quartzites. While all of them might easily have been transported by human agencies, none of them bears the slightest resemblance to an Indian artifact, nor do any of them indicate artificial wear or use prior to collection. Each of them is thoroughly rounded and smoothed and semi-polished, and all are of true Glacial type.

Throughout this period of investigation no boulders of large size such as those found in Lewis and Rowan counties by the

[2] Pan-American Geologist, Vol. XLII, pp. 125-132, 1924.

writer were discovered in central Kentucky. Their absence in central Kentucky, however, is far from substantiated. The results of the investigation should only be taken as indicating that Glacial boulders of large size are not numerous in this central northern portion of the Blue Grass region. The work done so far has been purely of a reconnaissance nature within the territory indicated. Future detailed county, or quadrangular, investigations within this area may positively establish the absence of large Glacial erratics here, or it may result in finds of outstanding importance.

Towards the close of the field season of 1924, samples of three of these unusual Kentucky pebbles and boulders were sent to the Canadian Geological Survey at Ottawa, Canada, with the request that these rocks, if possible, be traced back to their parent-ledge localities. Excellent cooperation resulted from this request as is indicated by the following report prepared by Dr. J. F. Wright, at the request and under the direction of Dr. W. H. Collins, Director of the Canadian Geological Survey, and forwarded to the writer December 2, 1924:

*Norite Gneiss No.* 5. This specimen is typical of a phase of the Buckingham series as described by Dr. M. E. Wilson. The distribution of the hypersthene phase of this series, as known at present in the Canadian pre-Cambrian, is limited to the district east of Ottawa and north of the Ottawa and St. Lawrence rivers. Dr. Wilson says that, except for the limonite stains, he can duplicate this specimen in his collection of Buckingham area specimens, but he has not yet written his geological report on this area and does not care to break his collection. Anorthosite-gabbro intrusives similar to the Buckingham series are abundant in the Adirondacks.

*Schistose Quartzite.* This specimen is similar to phases of the Grenville quartzite of the Ottawa-St. Lawrence valley of the Adirondack Mountains. West of Lake Superior the Seine series of Rainy lake, or the Wanipigow series of southeast Manitoba, are the only known series with rock-types similar to this specimen.

*Gray Porphyritic Granite-Gneiss.* This is a specimen of a very abundant and wide-spread rock-type in the Canadian pre-Cambrian. It is particularly abundant in the Laurentian highlands and the Adirondack Mountains. This specimen could be duplicated in almost any 20 mile square map-area in the southern part of the Canadian pre-Cambrian Shield.

*Conclusions.* Since hyperstene-bearing rocks are not wide-spread in the Canadian pre-Cambrian and the schistose quartzite and porphyritic granite-gneiss outcrop abundantly in the same area where the norite-gneiss is known to outcrop, it is reasonable to conclude that all three specimens came originally from the same general district. With our present knowledge of the limited distribution of this norite-type of intrusive to the Ottawa-St. Lawrence valley, and possibly in the Adirondack Mountains, it is concluded that these boulders were carried from some point northeast of a line from Ottawa to the southwest side of the Adirondack Mountains, and very probably from the area in Quebec between Ottawa and Quebec city.



The present status of this recent Glacial investigation in Kentucky appears to be, therefore, as follows: (1) A very thin, but wide-spread, mantle of Glacial material, in size both large and small, covers northern Kentucky from the Big Sandy River as far south as 38 degrees and 10 minutes, and as far west, at least, as the northwestward drainage of the Kentucky River. This Glacial material is found at various levels, but occurs in part at least at high levels, which cannot be accounted for satisfactorily by ponding. Such specimens as have been examined appear definitely to have been indigenous to the Ottawa-Quebec regions of Canada and possibly the Adirondack Mountains region of New York. Their widely disseminated characteristics coupled with the absence of accompanying Glacial shaping of topography, Glacial sands and gravels tends to substantiate the writer's early hypothesis that these erratics belong to the first Continental glaciation of the Pleistocene period and are equivalent to the Nebraskan or the Jerseyan epochs.

The result thus far obtained in these investigations indicate that a much broader territory in the Ohio Valley has been glaciated than has been supposed, and that a new and difficult chapter of American glaciation awaits the patient investigator in this region. The southern limits of this sheet were undoubtedly very attenuated. The earliest glaciation in the Mississippi Valley probably carried to the extreme southern limit but very little rock material drawn from remote Canadian points. It is not unusual, therefore, in the long time which has elapsed since the retreat of this earliest glaciation that the soft sedimentary material carried by this glacier should have disappeared entirely, leaving simply here and there a granite or quartzite boulder, of Canadian origin to tell the tale of the first and farthest Glacial advance into Kentucky.

# XIV.

## AGRICULTURAL PERSPECTIVE OF KENTUCKY GEOLOGY*

Since the quality and characteristics of all soils are so clearly an inheritance passed on by the decomposed parent rocks, it is quite worth while, from an agricultural point of view, to give serious consideration to the general principles of geology insofar, at least, as they have to do with the primary classification of the rocks and their habits of soil formation. In Kentucky a very interesting relationship exists. Here, perhaps, as well as anywhere, it is possible to see a fine balancing of the various operative factors. The several natural regions of this State may be considered distinctive types. It is the purpose of this article to set forth some of these geologic relationships and thereby enable the student of agricultural conditions to realize a little more clearly the real causes for certain soil conditions which are now fairly well defined in Kentucky.

The famous Blue Grass region is particularly instructive in this connection. Long intervals of time are necessary for the formation of all thick residual soils. Such deposits do not represent entirely the disintegration of sedimentary or igneous beds upon which they are superposed as is commonly thought to be the case. Quite contrary to this they are generally an agglomeration of residual materials resultant from the decomposition of many beds of rock much higher in the geological section. In many cases little is left with which to reconstruct theoretically hundreds of feet of the eroded strata. Such is definitely the case in the Blue Grass region of Kentucky. Here is a broad limestone upland, or plateau, attaining generally altitudes of 1000 feet above sea-level and covering an area of about 8,000 square miles.

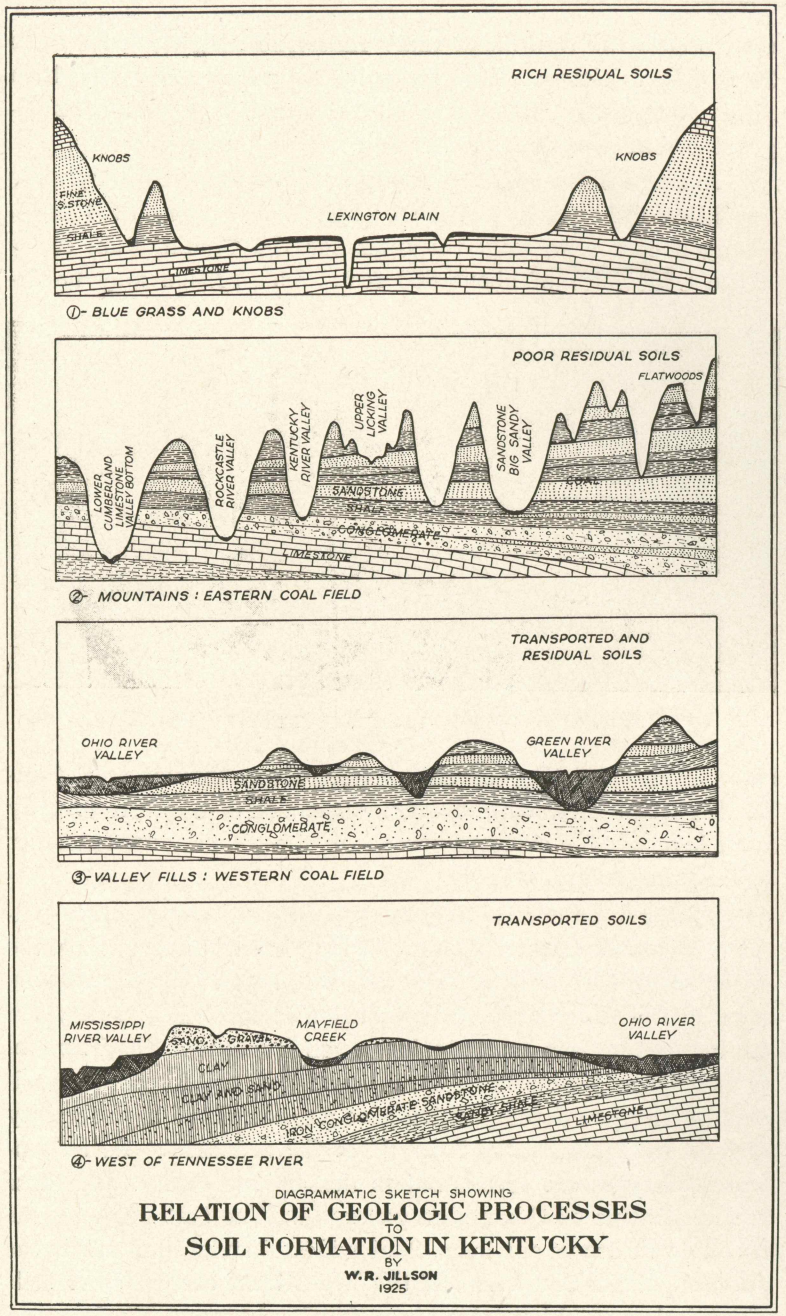
Structurally this region is a rather flat dome capping the Cincinnati Arch—that elongated geanticline extending from northern Ohio and Indiana southward into Alabama and Mississipi. The earliest regional uplifts along this great structure are

* Pan-American Geologist, Vol. XLIV, pp. 295-308 and 387-396, Nov. and Dec., 1925.

recorded in the Ordovic strata of central Kentucky. In Siluric times it was a low island for a long period, and this feature was again developed during a part of Devonic times. Indications are that it was submerged and subject to deposition during the time when the early Mississippian rocks were laid down, but probably it became a land area during the latter part of this period. During the time when the Coal Measures were forming it appears that north-central Kentucky may have been submerged for a short period at least. A connection was established during this time between the Eastern and Western coal-fields, through central Kentucky, covering parts of Casey, Russell, Adair, Taylor, Green, and Hart counties. It is known definitely that during the latter part of the period, and from thence to the present, including all Mesozoic and Cenozoic times, that this region was a land-area subject to weathering, rock-disintegration, and soil formation.

Presumably in Late Cretacic times this area was base-leveled; but all traces of this old level of erosion are now lost except the Jeptha Knob, in Shelby County, near Clay Village, which is now regarded in the nature of a monadnock. Subsequent uplift in Early Tertic times resulted in peneplanation, the topographic figure of which may still be seen in the gentle slopes in the vicinity of Lexington. Uplift of about 900 or 1,000 feet occurred again in the Pliocene or early Pleistocene times making possible the subsequent erosion and trenching seen along the Kentucky and Ohio rivers. The result of these cycles of erosion in a limestone area of domed figure is apparent to-day in the composition of the various soils of the Blue Grass region. These, described generally as red-brown, sandy loams, contain residuary particles from Pennsylvanian, Mississippian, Devonic and Ordovicic sediments. All of these formations now entirely removed were formerly hundreds of feet in thickness.

The oldest exposed rocks in Kentucky are found in the bed of the Kentucky River, near Camp Nelson and the mouth of the Dicks River, in the central part of the Blue Grass region. Massive limestones of Chazyan-Mohawkian age (Ordovicic), they are known locally as the High Bridge formation and are about 400 feet in thickness. Above these occur the Trenton, or Lexington limestones, about 250 feet in thickness. Higher in the rock col-




SOIL FORMATION IN KENTUCKY

umn occurs the Cynthiana shaly limestone ranging from 40 to 90 feet in thickness. This limestone completes the Mohawkian series of Ordovicic limestones in Kentucky, with a total stratigraphic thickness of about 720 feet.

Above are found the Eden shale (240 feet), the Maysville formation (230 feet), and the Richmond formation (210 feet), giving a composite total thickness for the Cincinnatian series (Late Ordovicic) of about 680 feet. This section may be described as consisting of many dark-blue, argillaceous, thin-bedded limestones, with many interbedded blue-green to gray shale layers. The siliceous content of these limestones increases to the southwest.

BLUE GRASS HEMP-FIELD, FAYETTE COUNTY

The Trenton and underlying Highbridge limestones are generally low in magnesia content, and high in carbonate of lime, the latter ranging from 90% to 95%. Magnesian beds occur, however, in the lower part of Highbridge formation, but they are not important from a standpoint of soil formation. The Trenton, or Lexington, limestones contain a number of phosphatic horizons which upon decomposition give rise to soils of high fertility such as are found in the Inner Blue Grass district. Seven separate soil-types are recognized in Jessamine County, and these are illustrative of this region generally. The best of these, the Hagerstown brown-silt loam, is of widest distribution and is the upland soil *par excellence* of the Blue Grass area. Other soils of much decreased importance are the clay loams, stony clays and stony loams of the steeper slopes close to the Kentucky River gorge. The restricted bottom soils, all alluvial and subject to overflow, are silt-loams derived directly from the strong lime soils of the uplands. In the river-bottoms, these soils are somewhat sandy, due to the fact that Kentucky River heads in the clastic Coal Measures of eastern Kentucky.

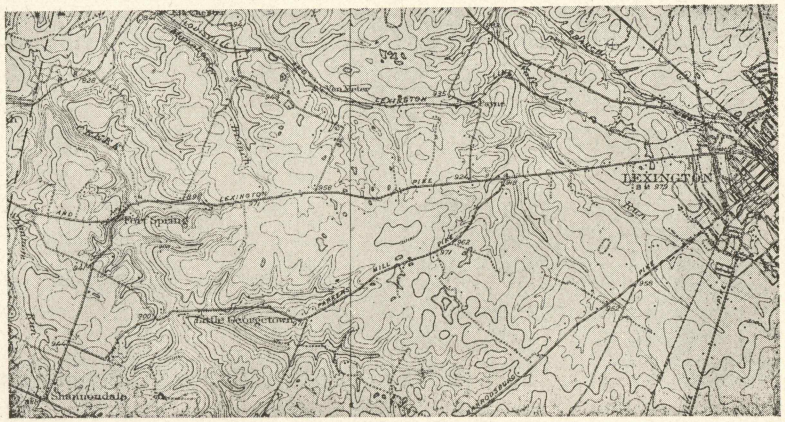


The Inner Blue Grass area contains about 2300 square miles and includes parts of Fayette, Clark, Bourbon, Jessamine, Boyle, Franklin, Scott and Harrison counties. All parts of this region are not, however, of the same agricultural value, due to down-faulting of elongated blocks which has preserved outliers of the Eden shale (Cincinnatian). Two notable instances of this geologic phenomenon may be referenced; one extending from near Great Crossings, in Scott County, to a point near Camp Pleasant, in Franklin County, a distance of about thirteen miles; and another from near Union Mills, in Jessamine County, through Fayette, east of Lexington, to a point near Hutchinson, in Bourbon County. This formation produces the well-known inferior Hagerstown clay and stony clay.

The main body of the Eden shale (Cincinnnatian) surrounds the Inner Blue Grass district, and consists of an area of about 2500 square miles. Being softer and decidedly less calcareous, though productive of good blue-grass, it is much more subject to erosion. The character of the topography of this belt is rougher, the soil being thinner and less productive. Plowed hillside fields frequently wash badly. Slips and slumps are common on all steep slopes, and a gradually increasing rubble of thin slabby limestones originally interbedded within the shale tends to retard intensive agriculture, and in some instances invite abandonment. Farm values on this outcrop are much reduced as compared to the Inner Blue Grass area because of purely geological causes. The counties found in this belt, in part or in whole, are: Grant, Harrison, Pendleton, Robertson, Nicholas, Montgomery, Clark, Madison, Garrard, Boyle, Mercer, Anderson, Shelby, Henry, Franklin and Owen. These counties contain, of course, especially in the valleys, many inliers of the highly productive lower Ordovicic limestones.

Surrounding the Eden shale-belt, and extending to the base of the Knobs, the "Outer Blue Grass" belt consists of about 3000

square miles. This is the outcrop of the two uppermost Cincinnatian (Ordovicic) formations—the Maysville and Richmond. It offers an interesting comparison with the areas already described. Here the geological section, about 450 feet in thickness, presents a considerable body of limestones, and the residual soils in consequence are much improved. In those parts of this area, such as are represented by Mason, northern Montgomery, eastern Nelson, western Shelby and Henry counties, where Pleistocene




LEXINGTON PLATEAU. ORIG. SC. 1:62,500; CONT. 20 FEET

dissection has not yet developed, excellent agricultural conditions obtain. The native soils here are deep and rich, comparing very favorably with those of the Inner Blue Grass area. The slopes reminiscent of the old Tertic peneplain, are gentle and easily and profitably tilled. In other portions of this belt, such as might be indicated by eastern Kenton, Campbell, Grant, and western Spencer counties, erosion results in leaving very steep slopes and little or no plateau land. In such areas the soil, while always better than that of the Eden shale-belt, is thinner and generally subject to washing into gullies. The counties included within the Outer Blue Grass belt are: Bracken, Mason, western Fleming, northern Bath, northern Montgomery, eastern Clark, central Madison, central Garrard, central Boyle, northern Marion, Washington, northern Nelson, western Spencer, western Shelby, western Henry, northwestern Owen, southeastern Trimble, Carroll, Gallatin, Boone, Campbell, Kenton, and northern Grant.



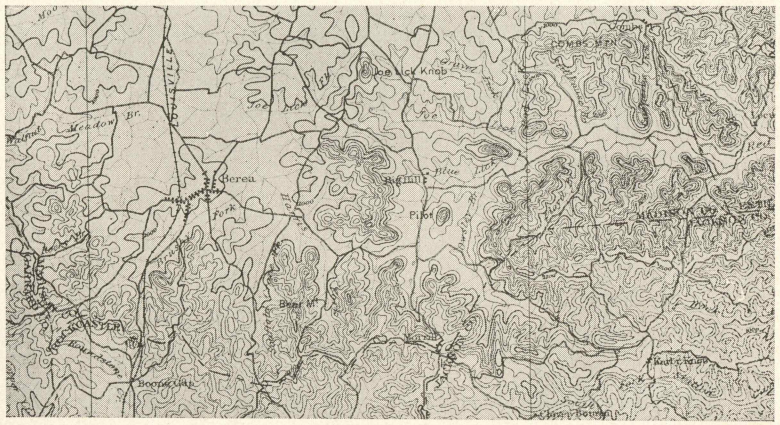
Sculptured into the surface of Kentucky like a nail-studded horseshoe open to the north, the "Knobs" belt surrounds the Blue Grass region and separates it from the Pennyroyal (Mississippian) plateau. Topographically, it is a rough area 10 to 20 miles in width and about 230 miles in extent. It strikes southwestward from the Ohio River, near Vanceburg, through Olympia, Clay City, and Irvine to Crab Orchard, thence to Lebanon, and from this point northwestward through New Haven and Shepherdsville to the Ohio River northeast of Louisville. Its area is about 3400 square miles. The Knobs region is characterized by a great number of more or less isolated conical hills resting upon the Tertic, or Lexington plain. The region exhibits a relief ranging from 400 to 700 feet. The hills generally are too steep to be of much agricultural value. Their soil covering is the Dekalb yellow-gray, generally somewhat stony, shale-loam, which is without exception the poorest in this belt. Most of the knobs are therefore timbered in small second or third growth pine, gum, oak and chestnut. When flat-topped they are usually capped by a relatively thin bed of Pottsville conglomerate sandstone, or Chester limestone. Elsewhere they are entirely conical to the peaks.

Stratigraphically, the rocks of the Knobs are of Siluric, Devonic, Mississippian, and occasionally Pennsylvanian ages. The complete section measures about 800 or 900 feet. It consists of shaly limestones, dolomitic limestones and thick-bedded shales from the first Siluric beds up through the Devonic and lower Mississippian sections. Superposed upon these are considerable thicknesses of even, cross-bedded, fine-grained siliceous beds (Logan-Warsaw formations) which are covered by massive cherty and oolitic limestones. The hills, well-exemplified by Mt. Minerva at Irvine, are thus actually outliers of the Mississippian plateau presenting a steep face towards the Blue Grass tract or lowland.

This great escarpment, known from earliest times as "Muldraugh's Hill," so *cuesta*-like in its figure, is one of the most striking topographical features of Kentucky. It has its original in the resistant qualities of the Pottsville conglomerate and the underlying Mississippian limestones and fine-grained sandstones, which capping the weaker shales and limestones of Devonic and

Siluric ages protects them from complete erosion. Wherever the basal Mississippian beds break through by stream action, broad flat lands with deep, residual, heavy-clay soils develop. This soil is known as the Dekalb silt loam. These areas are but slightly productive from an agricultural standpoint, due to the fact that they drain very poorly and are low in calcium carbonate, phosphates, and other important soil ingredients.

The Knobs region is one in which better methods of farming, including land-drainage and selection of crops, will do much to




KNOBS FEATURES. ORIG. SC. 1:62,500; CONT. 100 FEET

improve agricultural conditions. This is indicated in the notable results obtained on the experimental farm of Berea College, in Madison County. But it is not anticipated that this area can ever be made, even by the practice of the most modern and diligent methods, to compete successfully with the more fertile Blue Grass area adjoining. The geological phenomenon of differential erosion is responsible for hilly, "bad land" nature of the Knobs. Were it not for a humid climate and plentiful rainfall the physical aspect of the Knobs belt would be almost an exact duplication of the "Butte" country so typical of the high arid plains of the western United States.

Not more remotely than the Early Cretacic times the open circle of Ordovicic (Blue Grass) limestones with the Knobs belt was small. Through two complete cycles of peneplanation, and

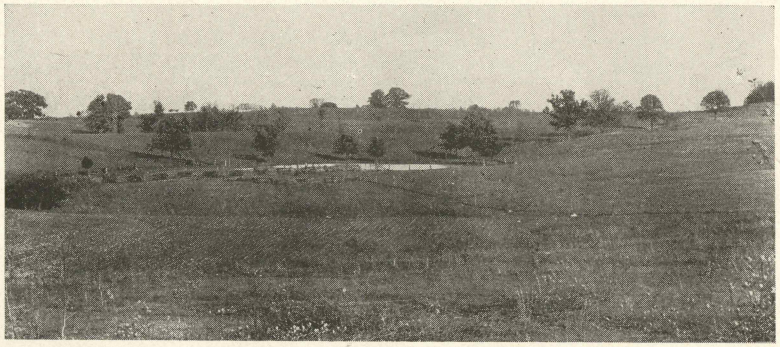


all of Cenozoic time, the ceaseless beveling by erosion has resulted in a very marked outward and down-dip migration of the Knobs belt, producing the extensive Blue Grass region as it is known to-day. And this process is actually, though of course very slowly, in operation at the present time. Theoretically it is no flight of fancy to forecast a time in the near geological future when the Knobs belt will have enlarged itself to such an extent as to increase the Blue Grass area 25% to 50%. Coincident with this expansion a large exposure of Ordovicic limestones will be developed, connecting the north-central part of Kentucky with the north-central portion of Tennessee through the upper Green and Cumberland River valleys.

Most irregular in outline of all the natural regions of Kentucky is the Mississippian plateau, commonly known throughout its southern extent as the "Pennyroyal" region. It presents a number of more or less distinct topographical districts. The region as a whole embraces about 7800 square miles, the best of which, from an agricultural standpoint, extends from Hodgenville through Elizabethtown to Hardinsburg, and southwest of a line drawn from Edmonton through Munfordville, Bowling Green, Russellville, Elkton, Hopkinsville and Cadiz. Well-defined geological factors involve this separation, as they do the development of the rough karst and sink-hole topography which follows the periphery of the Western coal-field in western Kentucky and the western margin of the Eastern coal-field in eastern Kentucky.

Broadly speaking, the Mississippian Plateau is the highest just west of the Eastern coal-field where elevations varying from 800 to 1000 feet are common. In central, southern and western Kentucky the summit elevations drop three to four hundred feet and regional altitudes varying from 400 to 600 feet are general. Throughout the Mississippian Plateau, particularly in those sections close to the Coal Measures both in eastern and western Kentucky, knobs exhibiting from 300 to 400 feet of resistant sandstones of the upper Mississippian and lower Pennsylvanian sections, are rather widely distributed. These are frequently called "Pilot Knobs" and are very prominent features of the landscape.

The physiography of the Mississippian Plateau, especially in that portion of south-central Kentucky drained by the Green and Cumberland rivers, is one of mature dissection. A rugged characteristic is developed here in thick beds characteristically siliceous. This group includes the New Providence-Fort Payne beds consisting of shales, shaly sandstones and intercalated limestones, and varies from 300 to 600 feet in thickness. Superposed upon it the Warsaw formation is a siliceous limestone ranging from 100 to 150 feet in thickness and of low solubility.



KARST REGION, MISSISSIPPIAN PLATEAU, WARREN COUNTY

The middle portion of the Mississippian section in Kentucky is decidedly calcareous, the principal outcrop consisting of the St. Louis and Ste. Genevieve limestones which are sometimes designated in a unit as the Mammoth Cave formation. This limestone varies from 100 to 600 feet in thickness, and is very soluble. As a result throughout the outcrop of these two limestones, from the vicinity of Fullerton, in northeastern Kentucky southwestward through the Carter Cave region, Olive Hill, Mt. Vernon, Somerset, Monticello and Albany to the Tennessee line, a very large number of sink-holes, coupled with caverns of greater or less extent, are developed. Subsurface drainage areas are well-defined in this region. The best upland soils of calcareous derivation are seen in southern Warren and Logan counties. They are classed in the Decatur, Clarksville, Shelbyville and Guthrie types. Of these the Decatur silt-loam is the best. The clay loam, gravelly loam, and stony clays are of considerably less importance.



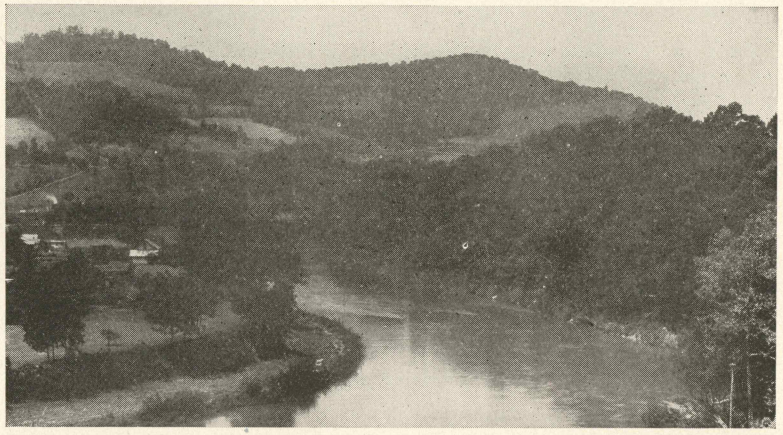
In western Kentucky the Mammoth Cave limestones attain their greatest thickness and purity in the Middle Green River section, and it is here surrounding the Mammoth Cave and adjacent cavern that the typical karst topography of North America is to be found. About twenty-five caverns of more or less importance, besides the Mammoth Cave, are explored in this region, and the extent of the subterranean passageways of this broad region while largely unknown and impossible of determination must be hundreds of miles in extent. Several cave levels, corresponding in elevation to terraces along the Green River, indicate periods of alternating arrested and accelerated dissection by this major stream. The karst topography and sink-hole belt of western Kentucky has been described in these pages.[1] Based upon detailed topographic mapping over representative areas it is estimated that 60,000 to 70,000 of these sinks occur on the Mississippian plateau in Kentucky.

The uppermost part of the Mississippian series presents an alternation of limestones, sandstones and shales. These formations develop very rough topography poorly suited to agriculture. The residual soils of this belt are thin and sandy, or heavy, silty or stony loams, low in phosphorus, and generally unproductive. They are classified in the Tilsit and Hanceville types. This belt of low fertility is due entirely to the lithological character of the upper Chester formation. Areally it closely bounds the periphery of the Western coal-field in southern Kentucky. It is absent or inconsiderable along the western border of the Eastern coal-field. Whatever Chester soils appear they unfortunately inherit much disintegrated sandy and quartz gravel detrital from the eroded overlying Pottsville formation.

In western Kentucky, in that portion lying between the Western coal-field and the Tennessee and Ohio rivers, an intricate fault pattern results in a differential uplift and depression of faulted blocks. These bringing to the surface rocks of varying lithologic character and resistance cause differential erosion. This feature, however, is offset to some degree by much quick, non-erosive, subterranean drainage and many intermittent streams. Disintegrated sands and conglomerates from the recently eroded Coal Measures, and considerable bodies of

smooth quartz and chert gravels from the basal Cretacic rocks operate to make the region less productive than it might be otherwise. The counties embraced within the Pennyroyal (Mississippian) plateau, in whole or in part are as follows: Lewis, Rowan, southern Bath, southern Montgomery, northern Montgomery, northern Powell, northwest Rockcastle, western Pulaski, southern Lincoln, Casey, Russell, northwestern Wayne, Clinton, Cumberland, Adair, Monroe, Metcalfe, Green, Taylor, Larue, Hardin, Meade, Breckinridge, northern Grayson, northern and southern Hart, southeastern Edmonson, Barren, Monroe, Allen, Warren, Simpson, southeastern Butler, Logan, Todd, Christian, Trigg, Lyon, Caldwell and Livingston.

Although widely separated geographically and very differ-



MOUNTAIN FARMS NEAR WILLIAMSBURG

ent topographically it would be logical to consider the two coalfields of Kentucky more or less jointly because of the similarity of their structural and stratigraphic geology. Both are basins as frequently referenced, though each, in fact, is a small part of a much larger unit. Neither is of course a basin in the ordinary sense of the word—a surficial depression—but rather in the geological sense a great structural depression, or geosyncline, now completely rock-filled. The Eastern coal-field is a part of the great Appalachian coal-field, extending from New York to Mississippi, while the Western coalfield is the southeastern tip of



the Eastern Interior coal-field extending northeastward from Kentucky through Indiana and Illinois into Iowa.

The Eastern coal-field of Kentucky comprises an area of approximately 10,500 square miles. It covers all of this State east of the line passing more or less irregularly southwestward from South Portsmouth, in Greenup County, to Albany in Clinton County. The topography of this entire area is either rough or rugged. It begins with the steep, west-facing, sinuous escarpment extending along the outcrop as already described. Stretching southeastward it continues across a maize of timbered, knife-like ridges and narrow meandering valleys to the Pine and Cumberland mountains—the State's border.

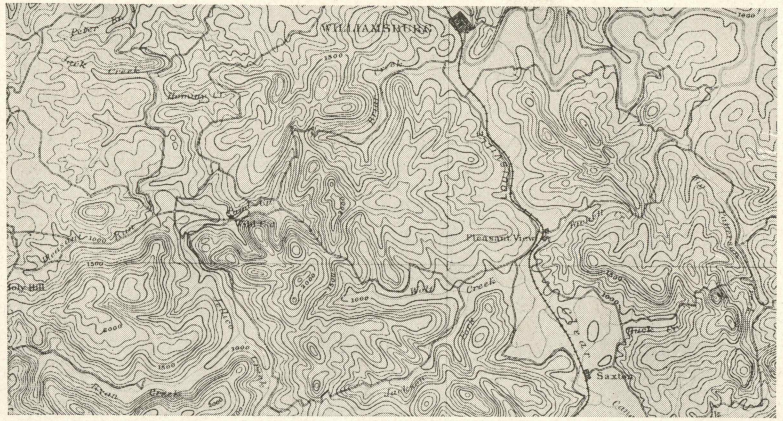
Physiographically the region is a maturely dissected, uplifted plain, known widely as the Cumberland Plateau. Summit elevations on the west outcrop range from 1,000 to 1,200 feet. Progressing eastward these rise to 1,500 and 1,800 feet in the Middle Big Sandy; while to the southeast these elevations increase to 2,000 and 2,200 feet, on ridge-tops immediately west of the Pine Mountain. Peak altitudes on this great range and its sister mountain, the Cumberland, vary from 2,500 to 3,500 feet, while summit elevations on the Big Black Mountain rising grandly between them are the highest in Kentucky—4,150 feet.

The Pine Mountain has its origin in a great faulted anticline, overthrust to the northwest two to five miles or more. The magnitude of this break is indicated by the fact that it extends continuously for over a hundred miles through which distance the Chattanooga shale is frequently brought to the surface along its northwest face. The Cumberland Mountain roughly parallel with the Pine Mountain is a part of the raggedly eroded, upturned, western flank of the Powell Valley anticline of Tennessee and Virginia, which, if it could be reconstructed, would rise to majestic heights of 15,000 or 20,000 feet.

As important integers in structural features of so vast proportions, developed by great crustal movements during the Appalachian Revolution at the close of the Paleozoic era, the Pine and Cumberland mountains assume individual significance. They are, in fact, the only mountains of true elevation in Kentucky.

The remainder of eastern Kentucky, though popularly described in song and story as "mountain country," does not in

fact exhibit mountains at all. The region is simply one of steep, winding ridges resultant from long-continued stream-erosion in the clastic rocks of a plateau which sharply tilted to the northwest. The local relief of the region, however, varies from 500 to 1,500 feet, which coupled with steep, rock-faced and timbered slopes is sufficient to be impressive, and justifies in the minds of many, including inexperienced travelers from the Blue Grass country and elsewhere, the very descriptive physical term "mountains."




KENTUCKY MOUNTAINS. ORIG. SC. 1:62,500; CONT. 100 FEET

Stratigraphically the rocks of the Eastern coal-field are divided into three sections: the Pottsville, the Allegheny, and the Conemaugh, all standard divisions in ascending order of the Pennsylvanian column. The uppermost part of this section, the Monongahela, formation is not represented in eastern Kentucky, nor are the overlying Permian rocks which close the Paleozoic era. The greater portion of eastern Kentucky is surfaced by rocks, sandstones, sandy conglomerates, shales and coals, of the Pottsville. These rocks, as a matter of fact, are to be found at all subsurface points within the coal-field. On the western outcrop they consist of sandy conglomerates and shales ranging from about 60 to 300 feet in thickness. In this conglomeratic country, exemplified by portions of Jackson, Rockcastle, Laurel, Pulaski and McCreary counties, the soils on the ridges are derived directly from the underlying coarse, clastic formations. As



a rule these soils are thin, sandy and gravelly. They contain little clay and are therefore but slightly retentive of moisture during periods of drouth. The valley soils of this subdivision of the Eastern coal-field are all alluvial and though productive are so limited in extent as to be of very slight economic value. Taken as a whole this ridge country is one in which unfavorable geological factors have combined to produce very poor agricultural conditions. And in addition an analysis of the area indicates that even with the best methods employed little permanent improvement can be expected.

Dipping down under the Allegheny formation, into the eastern Kentucky geosyncline, which extends northeastward from the Tennessee line through Whitley, Knox, Clay, Perry, Breathitt, Magoffin, Floyd and Martin counties, into West Virginia, the Pottsville formation thickens to immense proportions. It reappears in the vicinity of the Pine and Cumberland mountains where it has a measurable thickness varying from 3,250 to 4,000 feet. On its western outcrop one or two thin coals are found. These persist and take subsurface positions beside other new coals, sandstones and shales and thin limestones which weather in and thicken to the southeastward, until the Pine Mountain is reached where upwards of 25 or 40 separate coals are distinguishable. Some of these such as the No. 4, Fire Clay Coal, which carries a thin, flint, fire-clay parting, can be identified throughout the greater part of the coal-field. Others like the Elkhorn double seam (6 to 14 feet in thickness where mined at Jenkins, Fleming and McRoberts) are entirely unknown until they come to outcrop in southeastern Kentucky where they form very important commercial coals.

The Allegheny formation as represented in Kentucky, is of relatively slight significance. Consisting of alternating thick sandstones and shales, some commercial coals and thin limestones, it occurs as scatterel outliers occupying the highest ridges in the bottom of the eastern Kentucky geosyncline, from Knox County northeastward to the West Virginia line. At no point in this region is it ever more than 300 feet in thickness. In Martin County its extension to the north is interrupted by the east-west axis of the Paint Creek-Warfield anticline, but it again appears on the Lawrence County geosyncline where it attains a maximum

thickness of 200 feet. In this locality it contains some workable coals such as the Richardson, a correlative of the No. 5 Block coal of West Virginia.

The Conemaugh formation, as might be expected, is only found in Lawrence and Boyd counties, in the central part of the deep geosyncline. Like the underlying Allegheny formation it consists of sandstones, shales, coals and thin limestones attaining a maximum thickness of 350 feet, and only occurs as outliers on the highest hills. Although it carries coals regarded as important elsewhere, none are operated in Kentucky. The Conemaugh formation concludes the sequence of Coal Measures of eastern Kentucky which have a total maximum thickness of about 5,000 feet.

It is readily apparent that in a region of such great relief, where clastic sediments form virtually the entire geological section, agriculture should not be expected to attain more than a mediocum of success. Such is, indeed, the case in eastern Kentucky. Residual soils, generally silt, or sandy, clay-loams, are thin and of low productivity. Hillsides facing east and north generally show a deeper soil and are therefore better fitted for tilled lands than those exposed to the west and south which exhibit a closer adaptation to grass and retimbering. Nearly all old hillside fields will be found, upon examination, to have washed badly. The mountain slopes are, in fact, generally too steep for cultivation. That they are farmed, usually after an antiquated fashion, is a sad commentary on our established economic order, for the total produce thus obtained will scarcely make adequate return for value of the farm labor expended. Newly cleared land, though steep, will produce a fair crop—generally corn—for the first three or four years, after which time it becomes leached and washed beyond restoration.

Though very commonly such hillsides are tilled for many years after clearing, their productivity is exceedingly low. Except in an over-populated, retarded region such as the mountains of Kentucky, such tracts would never be formed. Reforestration is the only hope of these steep mountain slopes. Nothing else can keep such areas from degenerating into barren, gullied, hillside lands. Though effective and demonstratedly profitable over a term of years, woodlot and wornout hillside mountain farm reforestration has found but few followers in Kentucky. Nature,



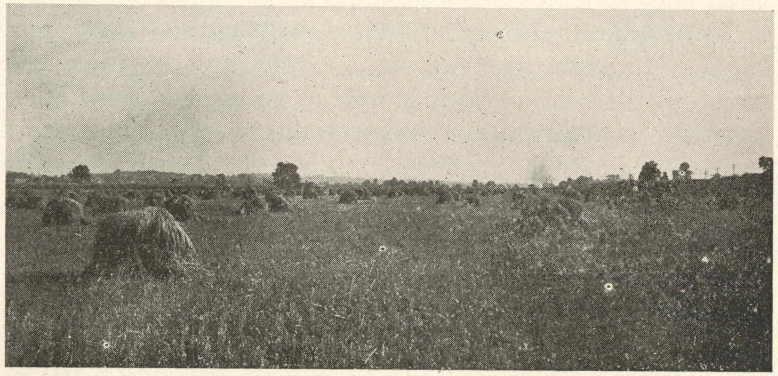
not man, appears to be the greatest friend of the old, gullied-mountain, corn-patch. Stepping in at the time of actual abandonment she blankets it with a small growth of green bushes and tree seedlings which, if protected from ranging herds of half starved cattle and sheep, will soon re-cover such slopes with an adequate stand of timber. In due time selected cuts from such naturally produced woodlands will outvalue any annual crop.

The residual, or "bottom," soils of the mountains are the best in this region. Along the main courses of the larger rivers, such as the Big Sandy, the Kentucky, and the Cumberland, the soils of the flood-plain are deep, well-watered and fairly productive. Consisting generally of heavy, sandy clay-loams, they are usually deficient in calcium carbonate, phosphorus and other important soil constituents. When drained they are reasonably productive, however, particularly if flood waters occasionally leave a good silt cover. In all low and poorly drained places, of which there are a good many, these soils remain heavy and unproductive. The comparative values of residual and transported soils are wellknown to the native farmer of eastern Kentucky, who until recently, has generally insisted on placing the public roadway in the waters of the small creek or branch whenever possible so that every bit of tillable bottom-soil might be conserved.

The Eastern Kentucky coal-field may be divided as has been suggested into two sections for convenience in agricultural investigations. The basis of the division is strictly geologcal having to do entirely with the areal distribution of the plateau, or upland forming Pottsville conglomerate, which over wide areas successfully resists mature dissection by the streams. The grouping follows: 1. The western margin of the Eastern coal-field where the towns, roads, habitations and farms are generally on the uplands. The counties representative of this group are: Laurel, Jackson and Wolfe. In the second group, comprising a very much larger area, the towns, dwellings, roads and tilled areas are in the bottoms, or close to drainage levels. Floyd, Letcher, Leslie, and Bell counties are representative. The following counties comprise the Eastern Kentucky coal-field: Greenup, Boyd, Carter, Elliott, Lawrence, southeastern Menifee, Morgan, Johnson, southeastern Powell, Wolfe, Magoffin, Pike, Leslie, Breathitt,

Knott, Letcher, Owsley, Jackson, southeastern Rockcastle, Larue, Perry, western Pulaski, Knox, Harlan, Whitley, McCreary, western Wayne and Bell.

Although the mineral resources of the Western coal-field are principally instrumental in carrying its great reputation abroad it is really a very important agricultural area. The reasons for this fact are plainly geologic. As a natural area in Kentucky the Western coal-field is deliminated by the outcrop of the basal conglomerate (Caseyville) of the Coal Measures. Superposed is a



OHIO RIVER BOTTOMS NEAR OWENSBORO

long section of alternating sandstones, shales, coals and thin limestones, all of which are Pennsylvanian sediments, and similar and comparable generally to those of eastern Kentucky both in lithology and sequence, except that in this part of the State the Monongahela section, which is absent in the East, having been removed by erosion, is present. A representative generalized section of the Western coal-field indicates the following divisional thicknesses of surface formations: Pottsville 1050 feet; Allegheny 400 feet; Conemaugh 1450 feet, and Monongahela 130 feet.

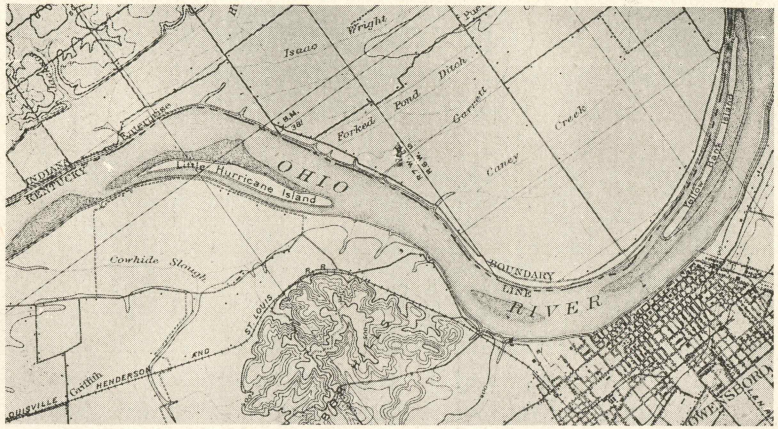
As already indicated this coal-field is the southern tip of the Eastern Interior field of the United States—a structural basin in fact with its greatest depth indicated by well-drilling and exposed stratigraphic section as located in Webster County. Topographically it is an area of low relief, exhibiting in certain districts of local structural disturbance rounded and frequently isolated flaring hills. The highest upland levels are about 700 feet above the sea, while the minimum levels along the Green and Tradewater rivers range down to 350 feet. Excepting some portions of the periphery where the erosion-resisting Caseyville conglomerate maintains a fairly prominent outline, practically all of the interior area may be described physiographically as mature, bordering upon old age. Its marked contrast in this respect to the Pennyroyal plain surrounding it and other natural regions of Kentucky has been brought about by a combination of geological circumstances.



These factors are for the most part plainly in evidence and are here briefly indicated. The region gives indication of having been a land area of probably low topographical figure from the close of the Paleozoic era, at which time the first Rough Creek disturbances were initiated. Cretacic base-leveling reduced the area to one of maximum uniformity of profile. A slight uplift in Early Tertic (Eocene) times gave opportunity for the development of a general relief of about 400 or 500 feet. Tertic peneplanation, beveling down this low plateau, was interrupted in process by a gradual regional subsidence which operated in the course of time to pond all of the major central drainage. Loss of gradient induced widespread valley-filling, the alluvium spreading far and wide as the sluggish overloaded streams gradually rose and meandered across their broadening flood-plains seeking outlet.

There is evidence at hand to indicate that the Pliocene-Pleistocene uplift of the Blue Grass region may have found some isostatic depressional compensation here in an area that had historically been weak or negative since the initiation of general emergence of the Ohio Valley region in late Mississippian time. During the Pleistocene there is also evidence at hand to prove the existence of widespread lacustrine conditions in this area induced by glaciation. The interpretation of terrace and delta levels will eventually indicate something of the detailed sequence of structural events in this region, while for the present it is sufficient to affirm that the Western coal-field has been one of progressive though non-continuous depression and aggradation throughout the greater part of Cenozoic times.

From an agricultural point of view this geological interpretation means much. The deposit in the valley bottoms, in wide contrast to eastern Kentucky, are alluviums ranging in thickness from 50 to 200 feet. The valley floors themselves are broad and aggraded in some instances to such an extent as to actually embarrass the drainage. In these localities artificial drains, or ditches, are necessary, and where instituted have proven very successful. The transported soils of these bottoms fall into three classes (1) gray silt-loam, (2) gray clay-loam, and (3) dark-




OHIO LOWLAND

brown clay-loam. They are inherently rich and fertile because of sands and muds derived from sandstones and shales of the Coal Measures to which is added at frequent times of high water fine clayey and calcareous silts brought down by the Green and Tradewater rivers, the headwaters of both of which are in the limestone area of the Pennyroyal plateau.

The residual soils, yellow silty to sandy loams, of the Western coal-fields are quite productive, but less so than the transported bottom soils. Due, however, to a rather intricate system of block-faulting radiating to the northeast across the Tradewater River a wider local variation is found in this group of soils than in the transported soils. Taken generally the residual soils two in number exist as rather thick, sandy clay-loams, sometimes rather stony, mantling the most of the low hill, many of which,



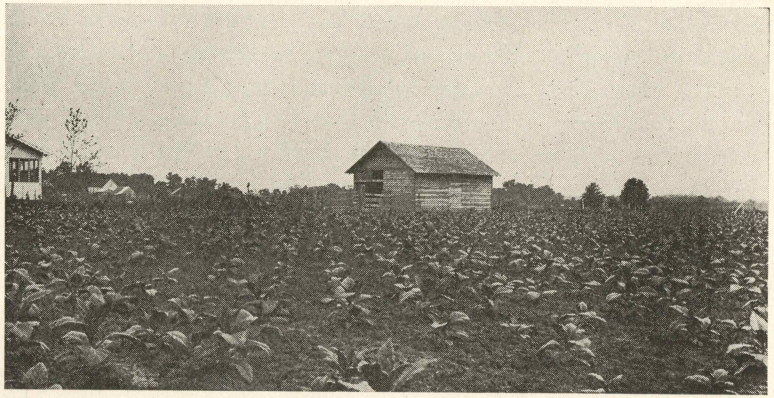
especially along the lower course of the Green River, are of so slight relief as to be slightly touched by erosion. In physical appearance these hills frequently bear a striking resemblance to low islands in a sea of alluvium.

The most unproductive part of the Western coal-field, aside from its periphery, is found in a narrow belt of broken uplands which follows the east-west course of the Rough Creek disturbance through the central part of the coal-field, from the vicinity of Leitchfield westward to the Ohio River a little south of Morgantown. This disturbance is complex. In part it is an unbroken anticline, elsewhere a series of *en echelon* faults. Sometimes the fault is normal but not infrequently it is overthrust to the north. In many places, as in Webster County, portions of the basal Caseyville conglomerate have been brought to the surface indicating a movement of about 1,000 to 1,500 feet. The age of the Rough Creek disturbance is undetermined exactly. Initiated at the close of the Paleozoic era, as were many of the Kentucky faults and folds, there is some indication that its largest expression may have been developed in post-Cretacic times, as it appears to have been but slightly affected if at all by the widespread peneplanation of this period. The extreme youth of some dissection in this limited structural upland is furthermore quite suggestive of movement accompanied by uplift in Late Tertic times, possibly the Pliocene-Pleistocene.

The counties embraced in the Western coal-field are of widely varying value both from an agricultural and mineral resource standpoint. The central counties, including Union, Webster, Hopkins, Muhlenberg and Ohio, are not only the best from a standpoint of soil productivity but they also contain the best and most highly commercialized coals, the No. 9 and No. 11 seams. In a continuation to the eastward of the geosyncline, southern Grayson and Edmonson counties exhibit the best deposits of rock asphalt. The counties in the Western coal-field are: Union, Henderson, Webster, Hopkins, Daviess, Hancock, Ohio, McLean, Muhlenberg, Butler, northern Edmonson, southern Grayson, as well as the northern tips of Warren, Logan, Todd, Christian, Caldwell and Crittenden counties.

Although small in area, the Jackson Purchase, containing about 4,500 square miles, is perhaps one of the most interesting

and solidly unified natural regions in Kentucky. As a province it encompasses all of the land west of the Tennessee River and south of the Ohio River in this State. It derives its popular name from General Andrew Jackson, who, with Governor Isaac Shelby, effected a treaty with the original landowners, the Chickasaw Indians, and purchased this area for the United States Government in 1818. It is the only part of Kentucky that is surveyed according to sections.



"BLACK PATCH" IN "PURCHASE" REGION

Topographically the Jackson Purchase area of Kentucky is a low, rather undulating plain ranging in elevation above sea-level from 500 feet along the southern boundary of Kentucky down to 300 feet on the Mississippi River front. Physiographically the region is in its youth, stream-dissection having hardly affected its rather level interior uplands. Close to the major streams, however, sharp gullies have worked their way back recently giving a broken characteristic to the landscape.

Considered from a geological point of view the Jackson Purchase is the most recent addition to the State of Kentucky. The sediments at the surface consist of several hundred feet of unconsolidated sands, gravels, clays and loess, and an occasional bed of lignite. Small areas of limestone are also exposed on a part of the east-flowing tributary drainage of the Tennessee River. These deposits are of Carbonic, Cretacic and Tertic ages. The loess is Pleistocene. The Mississippian and Cretacic rocks are only exposed in small areas in Calloway, Marshall, and McCracken counties. The Tertic (Lafayette) formations are found at the surface throughout the rest of the area, except in the lower valley bottoms where alluviums of recent age are present, and in the Mississippi River uplands where there is a considerable deposit of typical loess. Historically the Jackson Purchase is the northeastern tip of the old Gulf of Mexico which had its shore-line somewhat north of Cairo, Illinois, and the mouth of the Tennessee River during both the Cretacic and Tertic periods. Prior to Cretacic time, during the late Paleozoic and early Mesozoic eras, it appears to have been a land area in part at least.

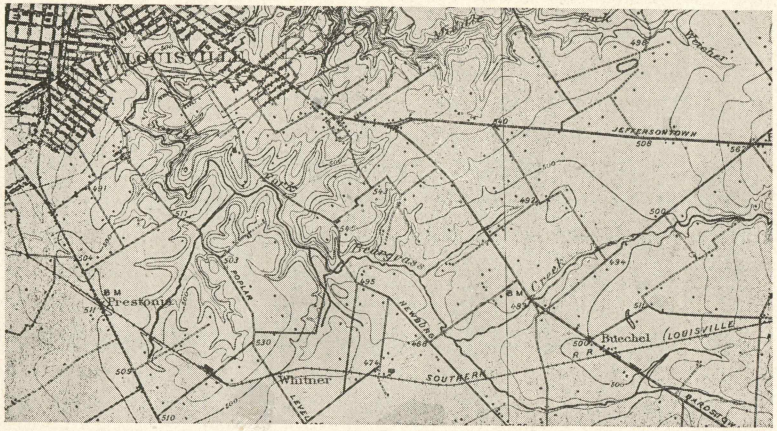


The soils in the Jackson Purchase area are quite different from those of any other part of Kentucky, due to the fact that they are for the most part based upon rather lately transported, unconsolidated clastic sediments. They are in fact unique being so recent (Tertic) as to have no inherited characteristic, yet old enough in part at least (Cretacic and Eocene) to be definitely excluded from the class of ordinary transported alluviums. The only truly residual soils in this region based upon rocks of Paleozoic age are found in a few scattered valley bottoms along the Tennessee River, in Caldwell and Marshall counties, where Mississippian limestones come to the surface. These residual soils where well-drained are rather fertile as might be expected in a region of such recent uplift. The mineral resources are few and of relatively small economic value. They consist of sands, clays, gravels and ground waters. The region is without prospect for oil or gas, coal or water-power.

The greater portion of the "Purchase" is covered by smooth upland some little distance back of the hilly stream margin, and is covered with a yellow silt-loam. This area represents the old prairie, or grass-covered portion of this region. These soils are productive except where they are poorly drained where they are white and "crawfishy." Hill areas and ridge-lands, which were originally timbered, exhibit a yellow-brown silt-loam, and this is the most extensive soil of the Jackson Purchase. Stretching eastward and superposed upon the high loess deposits of the Mississippi River uplands is found a yellow-brown loam. This bluff-land soil, 8 to 5 miles in width, grades imperceptibly into the yellow-brown silt-loams of the central uplands. It is the most

productive soil in the Jackson Purchase due to the fact that it is well drained and contains a considerable percentage of calcium carbonate. The bottom soils, all transported, are light-brown silts and sandy loams which have a rather high fertility. The counties included within the area are, Calloway, Marshall, Graves Fulton, Hickman, Carlisle, Ballard, and McCracken, the latter containing the lagest city, Paducah.

Agricultural lands in the Ohio River bottoms, covering about 1,000 square miles, may be logically considered separately




THE LOUISVILLE PLAIN

as they constitute a province not duplicated elsewhere in this State. This area consists of lowlands on the south, or Kentucky, shore of the river. It forms the most extended unified soil province in the State. Though the soils throughout this region are all transported, and somewhat similarly sourced, a varying structure and stratigraphy of the rocks underlying the extended area coupled with a changing composite character of rocks farther upstream gives a considerable variation to the soils of this district.

A case in point is seen in the bottom soils in Boyd and Greenup counties which, if analyzed, will not show as high a percentage of $CaCO_3$ as those of Henderson and Daviess counties, though both are situated in Coal Measures districts. The reason is seen in the character of the river water and its contained silts in these two widely separated areas. In Greenup and Boyd counties the Ohio River is relatively low in its calcium carbonate content due to the fact that but a restricted and distant area of limestone rocks has been drained. In the vicinity of Owensboro and Henderson the percentage of calcium carbonate in the Ohio River waters will show upon analysis to be much higher because at this point it has received all of the drainage of the large limestone areas of the Blue Grass region of Kentucky and Ohio, coupled with a considerable amount of drainage from the calcareous Pennyroyal plateau.



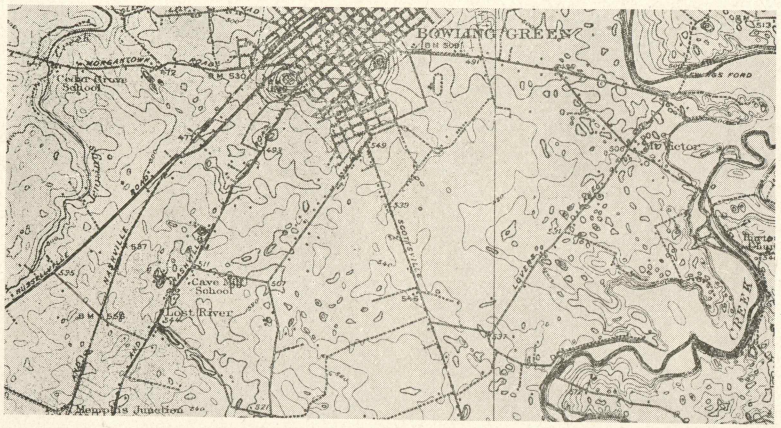
Another geological factor in favor of the Owensboro-Henderson district, from a standpoint of good soils, is seen in the progressive depression this region has undergone during geological time. This slow subsidence has resulted in a broadening of the Ohio Valley flood-plain, and overloading of both major and minor streams, and a larger deposition of sediments, particularly of fine silty carbonaceous material carried in suspension.

When examined throughout its course in Kentucky the Ohio River bottoms are also seen to have many physical variations. From Catlettsburg to Newport the river bottoms are relatively narrow being at many points not more than one-half to three-fourths of a mile wide. A notable exception to this generalization is seen just east of South Portsmouth, in Greenup County. From Covington to Louisville the bottoms expand to as much as two or two and one-half miles. In the vicinity of Louisville the old flood-plain is in many places five or six miles in width and grades almost imperceptibly into rich flat lands at the base of the Knobs. Below this point the Ohio River takes a rather narrow channel of comparatively recent cutting to get across the Mississippian outcrop which forms the western highland rim of the Blue Grass region.

Below Stephensport, however, the river bottoms begin to broaden out and are found as above indicated in their most extensive and richest expression from Hawesville to Paducah. From the mouth of the Tennessee River to its junction with the Mississippi River the Ohio River has a more restricted bottom land, but it is none the less productive. In its upper courses the bottoms of the Ohio River show very good drainage and relatively few wet or swampy places. Below Carrollton at the mouth of the Kentucky River poorly drained areas begin to be frequent,

though they are not numerous until Owensboro has been passed going down stream.

In the aggraded district of the Western coal-field sloughs and abandoned channels become frequent and are not only subject to periodic flooding but are generally too wet to be very productive or dependable from an agricultural standpoint. Uplift of the Cincinnati Arch with a nicely adjusted dissection above Covington has caused good bottom-land drainage conditions along the upper Ohio in Mason and adjoining counties. The




THE MISSISSIPPIAN PLATEAU

opposite is, of course, apparent at many points below Covington, and is very much in evidence at all points between Hawesville and Smithland.

To thoroughly understand the conditions of soil formation in the Ohio bottoms one must know something of the geological history of the river itself. Contrary to popular opinion the Ohio River is a comparatively recent stream. It did not exist prior to the early Glacial period. Many of the streams which empty into it, however, such as the Big Sandy, the Licking and the Kentucky, and probably others, were flowing in their present courses across Kentucky and thence to the north and west into the States of Ohio and Indiana where their ultimate drainage probably was divided between the Mississippi Valley and the Great Lakes basin At the onset of glaciation, as the first ice-sheet moved southward, the largest of these streams were ponded and their waters were



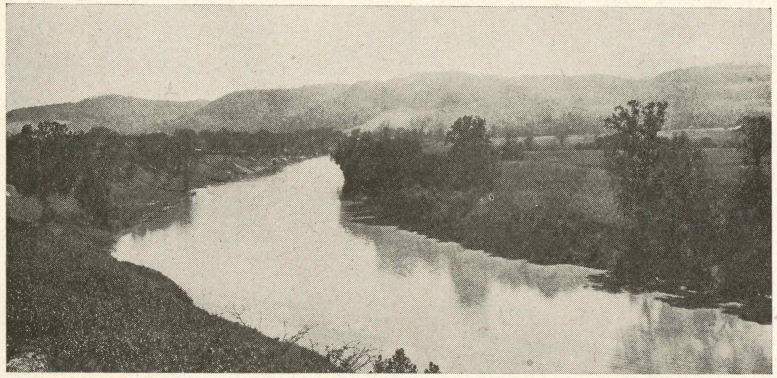
thrown back into their upper courses and raised to points sufficiently high to allow an overflow across certain low divides, or cols, from one drainage basin to another in a generally westward direction. One of a number of such cols existed just east of Manchester, Ohio.

The Big Sandy Valley reservoired the impounded waters of the Kanawha, Allegheny and Monongahela rivers as they came westward seeking outlet. In turn these waters were raised over the lowest divides separating the Big Sandy from the Licking River, and this again happened between the Licking and the Kentucky. The low cols which afforded the outlet for these ponded waters were composed of soft consolidated sediments. They were gradually removed giving eventually the course of the Ohio River as it is known today. The Ohio River is thus a composite stream laid down transversely across many northwestward flowing antecedent streams. During the processes of down-cutting of the low divides, or cols, deep silting took place at various points in the Ohio Valley between Catlettsburg and Louisville. Probably the greatest amount of silting occurred above Covington.

The result of this geological process is seen in a study of the soils to-day, for the character of the bottom soils above Covington is quite different from that which is found below Covington, and particularly below Louisville. Much of the very earliest silting of course has been removed, but a great deal of high-level silting forming transported soils now designated as (1) fine sandy loams of yellowish or brownish yellow color, and (2) sandy loams of brown or yellowish color such as those found in Mason County were formed under these conditions. These soils largely derived from the Coal Measures strata to the eastward and low in calcium carbonate are not very productive, due largely to a lack of organic matter. Between these sandy loams and the residual soils of the steeper slopes forming the principal valley of the Ohio there occurs a third bottom soil. It is a grayish-brown clay-loam, alluvial in character, and is distinctly a transported bottom soil, but differs widely from the sandy loams found in the true bottoms. This clay loam has been sourced in part at least from the steep residual soils adjoining and presents the characteristics of direct inheritance. Throughout the upper OhioValley

this soil is merged into the bottom soils, and in many places is not easily distinguishable from them. As a rule it is inclined to be acid and this coupled with the fact that it is generally poorly drained, results in a rather low productivity.

In the lower courses of the Ohio River three separate kinds of alluvial and transported soils are recognized. The most important bottom soil of this district is of a dark brown or tan-bark color known in the vicinity of Union County as the Yazoo clay. It is of recent and present formation. A strong, fertile soil, it



THE KNOBS ESCARPMENT ABOVE IRVINE

is capable of producing good yields of various crops, though it is generally in danger of overflow. Western Kentucky also exhibits along the Ohio River a silt loam which has been described logically as a gray bottom, or "made" land. It is a brown or yellowish silt loam mealy in texture and generally borders the edges of the streams.

One of the least important of bottom soils of the Ohio River is a fine, sandy loam, red-brown or yellowish in color and of medium texture but varying considerably in the percentage of clay which it contains. This soil is generally described as the "Miami" fine, sandy loam. It sometimes grades into almost a clear sand low in carbonaceous matter and unproductive. It is the product of frequent inundations and is found irregularly distributed throughout this district.

Thus the well established and widely known principles of rock-weathering and decay that results in soil formation find

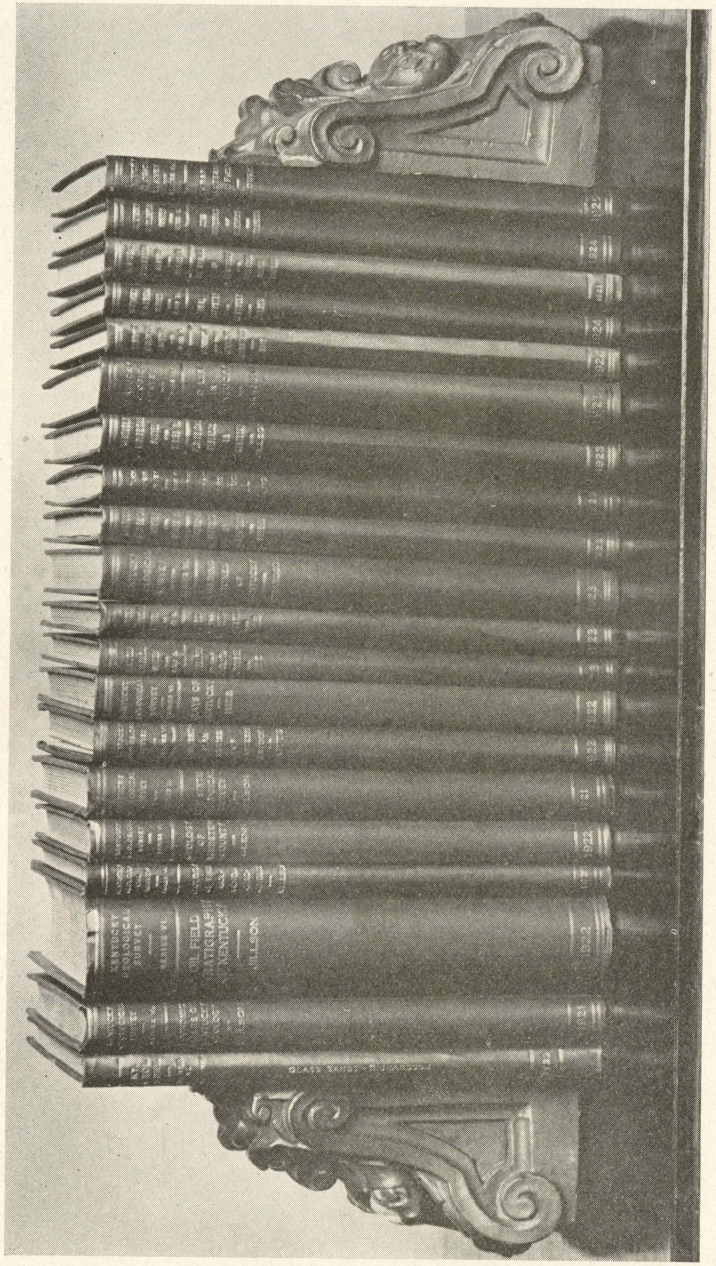


practical application. Scientific methods of classification not only assume as a basis for subdivision of the soils the actual rock parent but follows very closely the detailed stratigraphy and areal geology of the region. In Kentucky, our concrete example, variable geological conditions have conspired directly to produce the many different soil types. Some of them excellently illustrate the principles of soil formation generally.

In summation, it must be obvious that a very close relationship exists between the various soils and the underlying rocks, since the one is the direct product of the other. Either directly, as in the case of the residual soils found *in situ*, or indirectly, as instanced by the transported soils formed by stream agencies, all soils are to be classified on the basis of their parent rock.

Good, thick soils rich in calcium carbonate, phosphate and other desirable mineral constituents are likely originally to have been derived from massive, crystalline limestones with thin intercalated calcareous shales. Heavy sandy loams, infertile and unproductive, are likely to have been derived from thick-bedded shales and sandstones. Dark colored alluviums mantling a river floodplain are clearly an agglomeration of mineral particles resultant from rock-weathering and decay throughout the broad, upper reaches of the valley.

A geological map, like the accompanying one of Kentucky, thus also serves as a first-rate soil map.



PUBLICATIONS OF THE (SIXTH) KENTUCKY GEOLOGICAL SURVEY
(1920-1925)

# XV.

## ADMINISTRATIVE REPORT FOR THE (SIXTH) KENTUCKY GEOLOGICAL SURVEY*

**Years 1924 and 1925**

### Governing Statutes

The acts creating and governing the (Sixth) Kentucky Geological Survey and making appropriations for same are three and are entitled as follows:

I. "An act creating the Kentucky Geological Survey, designating its chief executive officer and his duties, and providing funds for its maintenance."[1]

This act, in conjunction with the Budget Bill of 1924, provided a total of $23,000.00 for the maintenance of the various activities of the Kentucky Geological Survey. The appropriation is divided into two funds: (1) Co-operative topographic mapping fund of $17,500.00, and (2) General geological fund of $23,000.00. In accordance with the statute the first fund was to have been used in a "dollar for dollar" co-operation with the U. S. Geological Survey in an extension of the topographical base map of Kentucky. Unfortunately the appropriation of $17,500.00, though passed by the legislature in 1924 as in the past, was vetoed, and so was not available. The topographical base mapping outlined in the governing statute, therefore, could not be carried forward during the last two years. The second fund was appropriated in the budget of 1924 and has been used for the maintenance of the Kentucky Geological Survey proper, payment of salaries, field expense, and miscellaneous charges, including printing.

II. "An act making an appropriation to the Kentucky Geological Survey, and declaring an emergency."[2]

Under this act funds in the sum of $17,000.00 were made available for geological investigations of various minerals of

* Ky. Geol. Survey, Series VI, Pamp. V, 54 p., 1925.
[1] Acts of the General Assembly of the Commonwealth of Kentucky, Chapter 34, p. 141, 1920.
[2] Acts of the General Assembly of the Commonwealth of Kentucky, Chapter 139, pp. 483-4-5. 1924.

economic importance in Kentucky. This act was sufficiently expansive to allow for printng and necessary administrative detail. The money thus provided has been used in accordance with the specifications of this act.

III. "An act to repeal, amend and re-enact section 3 of chapter 34 of the Acts of the General Assembly of Kentucky, 1920 session, touching the Kentucky Geological Survey."[3]

This act amending section 3, chapter 34, of the Acts of 1920, relating to the Kentucky Geological Survey, has operated to give the Director of the Survey a broader field of service to the people of Kentucky. By virtue of this act he becomes the curator of the collections of the Kentucky Geological Survey in the custody of the University of Kentucky at Lexington, and is authorized to arrange them for proper public preservation. He is given further authority to lecture on subjects pertaining to the geology, mineral and natural resources of Kentucky. The provisions of this Act have been complied with during the past biennium, as will be outlined later in the report.

## Personnel of the Survey

The personnel of geological assistants and trained office workers employed on the (Sixth) Kentucky Geological Survey during the past biennium is given below. All of these assistants with the exception of the Director's Secretary and Chief Clerk, are classified as "temporary employees" having been engaged for the summer field season of two or three months to do a special piece of geological or mineral resource investigation:

### DIRECTOR AND STATE GEOLOGIST

Willard Rouse Jillson, B. S., M. S., Sc. D., Frankfort, Kentucky.[4]

### ASSISTANT GEOLOGISTS

Charles Henry Richardson, Ph. D., Head of the Department of Mineralogy, Syracuse University, Syracuse, New York.

Stuart Weller, Ph. D., Head of the Department of Paleontology, University of Chicago, Chicago, Illinois.

Leonidas Chambers Glenn, Ph. D., Head of the Department of Geology, Vanderbilt University, Nashville, Tennessee.

Heinrich Ries, Ph. D., Head of the Department of Geology, Cornell University, Ithaca, New York.

[3] Acts of the General Assembly of the Commonwealth of Kentucky, Chapter 140, pp. 485-86. 1924.

[4] Permanent employee.



Arthur McQuiston Miller, M. A. (Retired), Head of the Department of Geology, University of Kentucky, Lexington, Kentucky.

Walter H. Bucher, Ph. D., Department of Geology, University of Cincinnati, Cincinnati, Ohio.

Frank Leverett, B. S., U. S. Geological Survey and Lecturer on Pleistocene Geology, University of Michigan, Ann Arbor, Michigan.

Walter Greeley Burroughs, M. S., Head of the Department of Geology, Berea College, Berea, Kentucky.

Louis W. Currier, M. S., Associate Professor of Mineralogy, Syracuse University, Syracuse, New York.

James S. Hudnall, B. S., Bowling Green, Kentucky.

J. Marvin Weller, B. S., University of Chicago, Chicago, Illinois.

Thomas F. Jackson, Ph. D., Bloomington, Indiana.

Charles Vernon Theis, C. E., University of Cincinnati, Cincinnati, Ohio.

Eugene S. Perry, B. S., University of Chicago, Chicago, Illinois.

Arthur C. McFarlan, Ph. D., Head of the Department of Geology, University of Kentucky, Lexington, Kentucky.

L. C. Robinson, S. M., University of Kentucky, Lexington, Ky.

### GEOLOGIC AIDES

Samuel M. Mayfield, B. S., Berea College, Berea, Kentucky.

George W. Pirtle, B. S., Elizabethtown, Ky.

George W. Morris, A. B., Harvard University, Cambridge, Mass.

John Grant Woodruff, B. S., Cadiz, Kentucky.

John Archer Culbertson, A. B., S. M., Hanover, Indiana.

Hubert Dixon Crider, B. S., Marion, Kentucky.

R. C. Lane, Fulton, Kentucky.

### GEOGRAPHERS

Darnell Haug Davis, Ph. D., Head of the Department of Geography, University of Minnesota, Minneapolis, Minnesota.

Carl O. Sauer, Ph. D., Head of Department of Geography, University of California, Berkeley, California.

### VARIOUS ASSISTANTS—TEMPORARY

W. D. Funkhouser, Ph. D., Head of the Department of Zoology, University of Kentucky, Lexington, Kentucky.

Charles Stevens Crouse, M. S., Professor of Metallurgy, University of Kentucky, Lexington, Kentucky, Oil Shale Technologist.

A. M. Peter, Sc. D., Head of the Department of Chemistry, Agricultural Experiment Station, University of Kentucky, Lexington, Kentucky, Chemist.

Warren R. King, C. E., U. S. Geological Survey, Division Water Resources, Chattanooga, Tennessee, Water Resource Engineer.

F. W. Bertsch, A. B., University of Cincinnati, Cincinnati, Ohio, Draftsman.
E. B. Boston, Columbia, Ky., Civil Engineer.
E. D. Phillips, Marion, Ky., Field Assistant.
A. B. Williams, Frankfort, Kentucky, Civil Engineer.
R. L. Harrison, Washington, D. C., Civil Engineer and Topographer.
J. F. Cusick, Frankfort, Kentucky, Photographer.
W. M. Easley, Frankfort, Kentucky, Draftsman.
Jack D. Jillson, Utica, New York, Rodman.
Otto A. Rothert, Louisville, Kentucky, Copy Reader and Indexer.
Wm. H. Lamberth, Memphis, Tennessee, Civil Engineer.
E. H. Marrs, Lawrenceburg, Kentucky, Accountant.
E. V. T. Caswell, Lexington, Kentucky, Copyist.
R. H. Dempf, Louisville, Kentucky, Rodman.
Miss L. E. Akers, Cave City, Kentucky, Copyist.
V. H. Wolford, Frankfort, Kentucky, Accountant.
D. B. Ventre, Chattanooga, Tennessee, Hydrographic Engineer.
James Watt Raine, Copy Reader, Berea, Kentucky.
F. O. Gardner, Lexington, Kentucky, Chemist.
W. J. Wright, Field Assistant, Frankfort, Kentucky.
G. H. Mays, Frankfort, Kentucky, Copy Reader.
W. A. Shelton, Vine Grove, Ky., Civil Engineer.
Crawford Dickey, Shelbyville, Kentucky, Assistant Topographer.
Miss M. E. Watts, Washington, D. C., Draftsman.
J. F. Martin, Washington, D. C., Civil Engineer.
Lewis Blackwell, Bowling Green, Kentucky, Civil Engineer.
Joseph L. Bissell, Frankfort, Kentucky, Draftsman.
W. A. Gibbons, Frankfort, Kentucky, Rodman.
P. B. Winn, Winchester, Kentucky, Field Assistant.
Miss C. E. Strange, Bowling Green, Kentucky, Copyist.
Miss H. E. Miller, Big Bone, Kentucky, Field Assistant.
Miss C. B. McNamara, Frankfort, Kentucky, Secretary.[5]
Miss H. M. Scott, Frankfort, Kentucky, Chief Clerk.[5]
J. M. Frasure, Chief Clerk (Resigned.)[5]

## Summary of Activities

During the past biennium (1924-25) the work of the Kentucky Geological Survey has consisted of various detailed and general geological and mineral resource investigations distributed throughout Kentucky. In the fluorspar field of Livingston and Crittenden counties, Dr. Stuart Weller has continued his studies of the structure and stratigraphy of the Mississippian rocks and their contained deposits of fluorspar. His work has been confined chiefly to the Cave-in-Rock Quadrangle. The completion of this work has been delayed due to the necessary revision of the topographic base map in two or three small areas north of Marion. The manuscript covering this work, the preparation of which was announced in a previous administrative report, has now been revised, and with a geological map, is ready for the printer, but has not been published, due to lack of funds.

[5] Permanent employees.



A report of state-wide significance entitled "Mineralogy of Kentucky," has been prepared by Dr. Chas. H. Richardson. In writing this new report Dr. Richardson has made use of his field notes prepared during four years of work on the Kentucky Geological Survey concerning various minerals occurring either in specific or commercial quantity in Kentucky. During the past year Dr. Richardson has executed the field work and prepared two reports which will be published as a unit volume No. 29, as follows: Part 1, "Molding Sands of Kentucky," and Part 2, "Cement Materials of Kentucky." Each of these reports is statewide in its application, and they are in direct conformity with the recent act of the legislature providing for detailed investigation of mineral resources and roads and cement materials.

During the past two years Dr. L. C. Glenn has been engaged in a study of the coal measures of the entire Western Kentucky Coal Field, the plan being to map the various important commercial coals of this field and run the outcrops of the major stratigraphic units, the Pottsville, Allegheny, Conemaugh and Monongahela. Field work in 1926 will be required to complete the field work, after which the office work of manuscript preparation will be rapidly advanced.

A reconnaissance report entitled "Surface Formations of Northern Kentucky," has been prepared as a result of field work executed by Professor Frank Leverett, geologist of the U. S. Geological Survey, during the field season of 1924. During 1925 Professor Leverett confined himself almost entirely to the examination of the Peistocene deposits and surface features of Northern and Central Kentucky.

Dr. Walter H. Bucher, whose field studies of the geology of the Jeptha Knob in Shelby County, Kentucky, were completed as announced in the last administrative report, has revised his manuscript following detailed investigation of a considerable body of pertinent geological literature of Europe while abroad

last year. This report is now published and available in volume 21, Series VI, Ky. Geol. Survey, "Oil Shales of Kentucky."

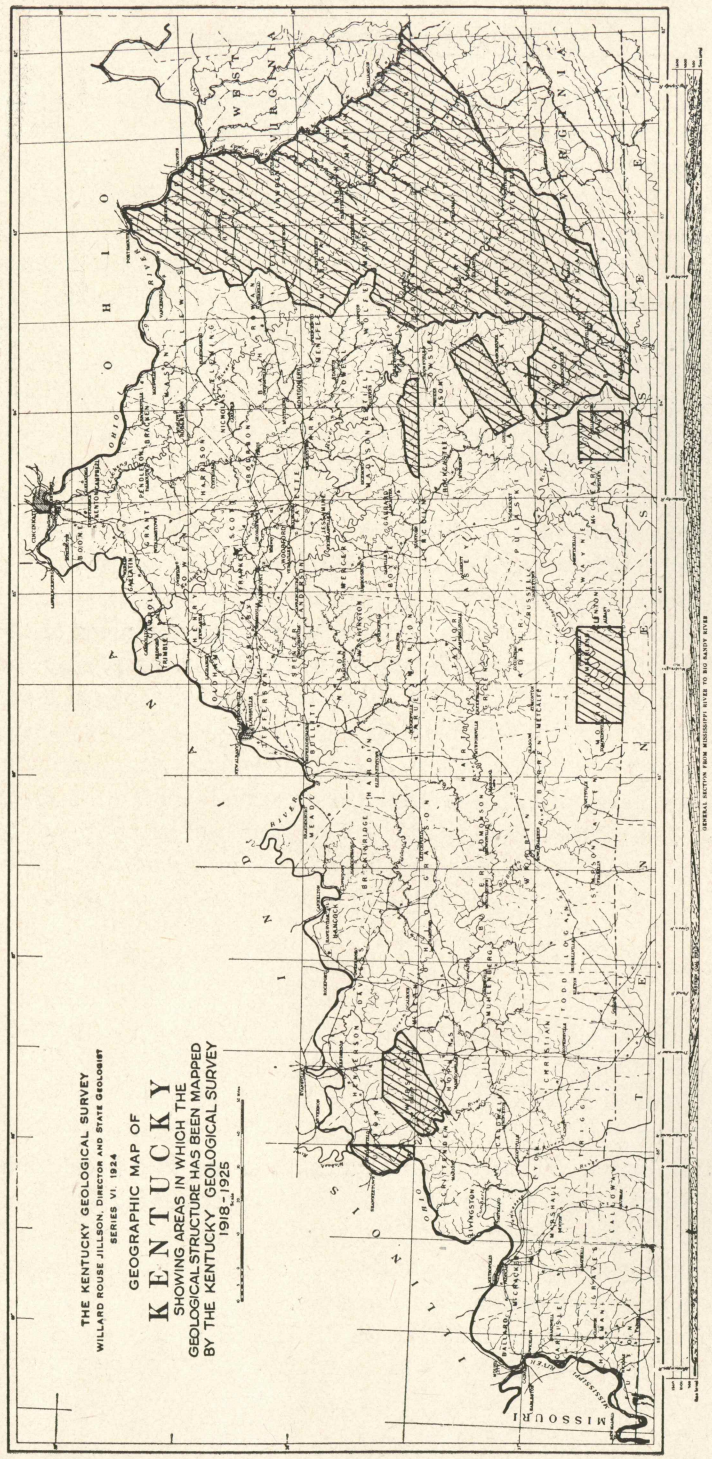
Dr. Carl O. Sauer, with a corps of assistants, has been engaged during the last three years in executing the field work and preparing manuscript of the geography of the Mississippian plateau in Kentucky. This manuscript with drawings and photographic illustrations has now been finished and is ready for the printer. It is numbered volume 25, and is entitled "Geography of the Pennyroyal Plateau." It is in every way a very first-class piece of modern scientific geography and will be of much value in assisting Kentuckians to interpret the many natural and mineral resource opportunities present in this extensive region.

Within the last year volume VIII of Series VI, entitled, "The Clay Deposits of Kentucky," became exhausted, due to an unusually insistent demand. Accordingly Dr. H. Ries, of Cornell University, who originally prepared this report, was re-engaged to revise the report and bring it up-to-date. The revised manuscript with much new data is now completed and ready for the state printer.

During the past two years Mr. James S. Hudnall has been engaged in an extension of structural and stratigraphic studies in the Eastern Kentucky Coal Field, these having resulted in published oil and gas structural maps I the Paint Creek Uplift, II Boyd, III Perry, and IV Leslie counties. His work is also represented in part of published maps of V Knox, VI Carter, VII Morgan and a regional structural map of parts of VIII Estill, Jackson, Lee, Rockcastle and Madison counties.

Professor Louis W. Currier commenced the study in 1925 of the vein ores of Kentucky. Examinations completed are confined to the Blue Grass Region, but during 1926 will be extended to Central and Western Kentucky and will include a detailed investigation of all important deposits of lead, zinc, barite, calcite and fluorspar in this state.

In accordance with an act of the last legislature special investigations relative to the occurrence of rock asphalt in western Kentucky have been undertaken for the Survey by J. Marvin Weller and Thomas F. Jackson; these investigations being confined largely to Edmonson County, the heart of the rock asphalt field of the state. The field work and subsequent manuscript



for this report have been completed, and this work is now ready for the state printer. It is known as Volume 28, "Geology of Edmonson County."

Dr. W. D. Funkhouser has been engaged during the past two years in preparing a report on the prehistoric life of Kentucky. This report discusses the occurrence of animal and human life within this Commonwealth before the advent of civilized explorers. Much of the volume will have to do with the influence of the geology and physiography upon the various life forms, particularly Mound Builders and the Indian. While distinctly not archaelogical in its central motive, this report will have much in it of achaeological as well as general geological interest.

During the past biennium the Survey has been engaged in the preparation of a new drainage and political base map of Kentucky, which has been very badly needed because of the great inaccuracy of the one now in use. This work was undertaken byMr. R. L. Harrison and Mr. W. H. Gill, engineers of the U. S. Geological Survey, Washington, D. C. In preparing the new base map the best and most modern detailed regional maps were used. For the first time in the history of Kentucky maps of one kind or another and of sufficient accuracy were available for every part of the state. Detailed topographic maps for about 51% of Kentucky were used. In the remaining areas county maps generally of the scale of 1 inch to the mile were used. The resulting state map scale 1:500,000 is very detailed and accurate. As soon as this map is issued Kentucky will have a base map upon which the state, county, political, drainage and other lines, including the through highways, the cities and the towns are accurately located geographically. This map is now in the hands of the printer and will be issued during the coming year.

Detailed areal geological maps have been made of Lewis County by Prof. E. S. Perry, and of Morgan County by Prof L. C. Robinson. The Morgan County area has also been made the subject of a preliminary geological report, which has been written by Prof. Robinson. It discusses the stratigraphic and structural geology of the region and outlines the mineral resources and their economic importance.

During the year 1924 Mr. R. L. Harrison has prepared a manuscript topographic map of Kentucky, scale 1:500,000. The



interval of this map is 200 feet. The data used in this map was derived directly from topographic maps covering 51% of the state, and sufficiently distributed to reveal the topographical characteristics of Kentucky. Areas intervening were run in with aneroid in more or less detail by various workers on the Kentucky Geological Survey. In this collaborative manner there were supplied sufficient data to prepare the first topographical base map of Kentucky. This manuscript is now completed and in the hands of the printer, and will be issued using the new base map some time during the coming year. Kentucky takes high rank in preparing this map of the Commonwealth, as such maps have only been prepared by one or two other states.

The past field season of 1925 has been largely devoted by the Kentucky Geological Survey to the running of outcrops throughout the state in preparation, under the direction of the State Geologist Dr. W. R. Jillson, of a new and much needed geological map of Kentucky. The eastern coal field was divided into three parts, the Pottsville, Allegheny and Conemaugh, by Mr. James S. Hudnall and Dr. C. T. Wentworth. Mr. Hudnall's province consisted of the area north of the Pine Mountain. Dr. Wentworth's province consisted of the Middlesboro syncline. The western Kentucky coal field as referenced above was divided by Dr. L. C. Glenn into the Pottsville, Allegheny, Conemaugh and Monongahela. The Mississippian outcrop was covered in reconnaissance by Dr. Stuart Weller, who was assisted by Prof. A. C. MacFarlan in eastern Kentucky, and by Dr. Richard Foster Flint and Mr. J. M. Weller in central and western Kentucky. These men, with their assistants, divided the Mississippian formations into the Chester, Meramec and Osage groups and ran the areal outcrop of same.

Dr. T. E. Savage with a party completed studies of the entire Devonian outcrop in Kentucky. This work will be used on the new geological map of the state and will also lead to detailed outcrop, maps and a reconnaissance report covering stratigraphic and structural as well as areal features of the entire Devonian in Kentucky.

## Work by the Director

The State Geologist, Dr. Willard Rouse Jillson, in addition to his administrative and executive duties as Director of the Kentucky Geological Survey, has found time to carry forward considerable geological research during the past biennium, and has published a number of shorter articles on economic, physiographic and glacial geology of Kentucky. Several of these papers were originally presented by him as addresses before educational, scientific and lay bodies in Kentucky and elsewhere. A list of these shorter publications and books follows:

ADMINISTRATIVE REPORT (1922-1923)
Covering the activities of the Sixth Kentucky Geological Survey. Prepared for the Governor and the Legislature. 1 illus., 1 topographic index map. Kentucky Geological Survey, Series VI. 1923.

KENTUCKY STATE PARKS:
A brief presentation of the Geology and Topography of Some Proposed State Park Areas Based upon Original Field Investigation. 85 pages. Presidential Address, Kentucky Academy of Science. Kentucky Geological Survey, Frankfort, Ky. 1924.

FAULT PATTERN OF KENTUCKY:
The Pan-American Geologist. Vol. XLI., Feb., 1924. Geol. Pub. Co., Des Moines, Iowa.

NEW RELIEF MAP OF KENTUCKY:
The Pan-American Geologist, Vol. XLI., Feb.., 1924. Geol. Pub. Co., Des Moines, Iowa.

KENTUCKY CANNEL COALS:
The Pan-American Geologist, Vol. XLI., March, 1924, pp. 87-98. Geol. Pub. Co., Des Moines, Iowa.

PRIMEVAL TRACTS OF KENTUCKY:
The Pan-American Geologist, Vol. XLI, April, 1924, pp. 169-175. Geol. Pub. Co., Des Moines.

KENTUCKY ROCK ASPHALT:
The Pan-American Geologist, Vol. XLI, May, 1924, pp. 251-259. Geol. Pub. Co., Des Moines.

AMERICAN KARST COUNTRY:
The Pan-American Geologist, Vol. XLII, August, 1924. Geol. Pub. Co., Des Moines, 1924.

GLACIAL PEBBLES IN EASTERN KENTUCKY:
Science, Aug. 1, 1924, Vol. LX, No. 1544, pp. 101-102, 1924.

COAL INDUSTRY IN KENTUCKY:
Kentucky Geological Survey, Series VI, Vol. XX, 164 pp. 1924.

GLACIATION IN EASTERN KENTUCKY:
The Pan-American Geologist, Vol. XLII, pp. 125-133, Sept., 1924.
Presented before the Geological section of the British Association for the Advancement of Science at Toronto, Canada, Aug. 11, 1924. Geol. Pub. Co., Des Moines, 1924.

EARLY MINERAL EXPLORATIONS IN THE MISSISSIPPI VALLEY:
(1540-1840) Pub. 31, Ill. State Hist. Lib. Trans. of the Ill. State Hist. Soc., Year 1924, pp. 41-57, Springfield, 1924.

OUTLOOK FOR MINERAL DEVELOPMENT IN KENTUCKY:
The South's Development-Manufacturers' Record, Part II, pp. 374-75, Baltimore, Dec. 11, 1924.

AGRICULTURAL PERSPECTIVE OF KENTUCKY GEOLOGY:
The Pan-American Geologist, Vol. XLIV, Nov. and Dec., 1925, pp. 295, 308, 387 and 396. Geol. Pub. Co., Des Moines. 1925. Also with additions in 26th Biennial Report, Ky. State Dept. of Agr., pp. 103-132, illustrated, Frankfort, Ky., Dec., 1925.

RESUME OF KENTUCKY MINERAL RESOURCES:
26th Biennial Report Kentucky State Department of Agriculture, pp. 19-25, illustrated, Frankfort, Ky., Dec., 1925.

STATE PARKS IN KENTUCKY:
Anniversary Address Perryville Battlefield, Perryville, Ky., Oct., 1925. 26th Biennial Report, Ky. State Dept. of Agr., pp. 159-....., illustrated, Dec., 1925.

RECENT GEOLOGICAL INVESTIGATIONS IN KENTUCKY:
The Kentucky Outlook, Vol. II, No. 2, p. 6, Jan. 9, 1926.

Dr. W. R. Jillson has now in preparation a manuscript entitled, "The Topography of Kentucky," which will be Volume 30 in the Survey's series.* This report describes the surface features of this state and their geological causes. It also outlines the influence of these physiographic features on the social and economic development of the people of this state. The Director has prepared a new small geological map of Kentucky showing oil and gas, coal and fluorspar, and rock asphalt fields. This map has been published and is now available. Dr. Jillson has also executed the field work necessary to secure the data and has prepared a new map of the subsurface structural geology of Boyd County, using as a datum plane the black Sunbury (Mississippian) shale. This map has been published and has been much in demand in this part of Kentucky.

The Director of the Kentucky Geological Survey was made Curator of the collections of the Survey lodged at the University of Kentucky by an act of the last (1924) legislature. During the past biennium the Director has taken steps looking toward

* The volume referred to is the one now in hand.

the rearrangement of these important mineral collections so as to enhance their specific, comparative and educational value to the people of the state. This work is now going forward and will be continued during the next two years.

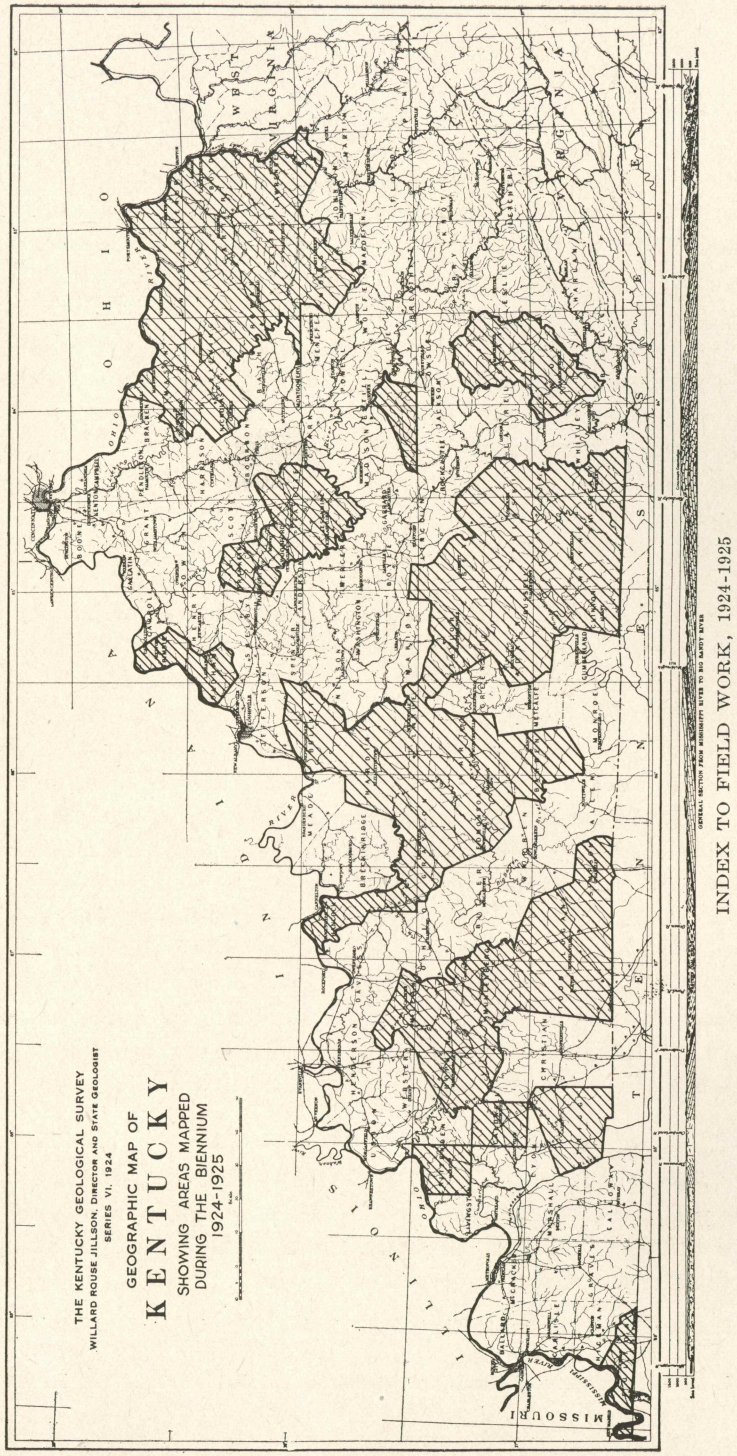
### New Maps of Counties

In the course of the several investigations carried on during the past two years all of the counties in Kentucky have been included, some generally, some in detail. Most of the counties appear in all of the reports either directly or indirectly. Detailed geological investigations, however, have necessarily had to be confined to areas which had been previously topographically base mapped, as no other accurate base map exists on which accurate elevations are to be found.

Within the last biennium the Kentucky Geological Survey under the personal supervision of the State Geologist, has prepared a series of new reconnaissance black and white geographical county maps. Most of these are for counties which have never been mapped. The scale in most instances is: 1 inch equals one mile. These maps are essentially road and stream maps. They do not carry elevations, and are not suitable for detailed geological work, but are suitable for and much in demand by tourists, farmers, road engineers, sanitary engineers, contractors, geologists and many others. The counties so mapped were Fulton, Trigg, Oldham, Mason, Todd, Logan, Simpson, Bullitt, Hardin, Larue, Hart, Casey, Trimble, Russell, Pulaski, McCreary, Robertson, Nicholas, Rowan and Greenup—a total of twenty.

Detailed oil and gas structural geological maps have been prepared for (1) Paint Creek Uplift, showing portions of Floyd, Johnson, Magoffin, Morgan, Lawrence and Elliott counties, Ky.; (2) Knox County; (3) region south of Berea, including portions of Estill, Lee, Jackson, Madison and Rockcastle counties; (4) for a portion of Elliott County; (5) Carter County; (6) Boyd County; (7) Greenup County, and (8) portions of Cumberland, Monroe and Clinton counties.

New oil and gas maps have been prepared for Taylor, Clinton, Wayne and Barren counties. An areal geological and structural oil and gas map has been prepared for Morgan County by L. C. Robinson and J. S. Hudnall; and an areal geological map has been prepared for Lewis County by Prof. E. S. Perry. A



geological map of Adair County has been prepared from the notes of Professor A. M. Miller. Dr. A. C. MacFarlan and George W. Pirtle have been engaged in preparing a geological map of Jessamine County at various times during the past two years. With Prof. L. C. Robinson Dr. MacFarlan is now engaged in preparing a geological map of Fayette County, the base of which is being prepared by W. C. Eyl.

A recapitulation of the mapping program of the Kentucky Geological Survey during the past two years as outlined above indicates that forty-five (45) counties have been mapped either geographically or for some particular mineral. The scale used in most instances has been 1 inch to the mile. The maps are detailed enough to show practically every dwelling within the areas covered. As a result the demand for these maps has been very great, and every indication points to the fact that it will increase. The total area mapped in detail during the past biennium is about 15,850 square miles or about 38% of the area of Kentucky.

In addition to its several activities as ountlined above the Kentucky Geological Survey has continued during the past two years its co-operative program of water resource work with the U. S. Geological Survey. Mr. Warren R. King, engineer of the U. S. Geological Survey, with offices in Chattanooga, Tenn., has been in charge of the work of stream gauging and flow measurements on the Green, Kentucky, Big Sandy and Cumberland rivers. Funds for this work have been furnished by the U. S. Geological Survey, while the Kentucky Geological Survey has undertaken to publish the records. The Kentucky Geological Survey has also co-operated with the U. S. Bureau of Mines and the U. S. Bureau of the Census in securing information relative to some of the mineral resources produced in Kentucky.

## New Bound Publications

The following new publications have been prepared during the past biennium, 1924-25. Some of these, such as Vol. 24 and Vol. 27, have already been published. Others are now being printed or are ready for the state printer.

Vol. 8.—Clay Deposits of Kentucky. 2nd Ed. Revised. H. Ries, 1925 (Mss.)

Vol. 23.—Geography of the Blue Grass. D. H. Davis. 1925 (In Press.)



Vol. 24.—Geography of the Western Coal Field W. G. Burroughs. 1925.

Vol. 25.—Geography of the Pennyroyal. C. O. Sauer. 1925. (In Press.)

Vol. 26.—Geology of Cave-in-Rock Quad. S. Weller. 1925. (In Press.)

Vol. 27.—Mineralogy of Kentucky. C. H. Richardson. 1925.

Vol. 28.—Geology of Edmonson County. J. M. Weller. 1925. (In Press.)

Vol. 29.—Molding Sands and Cement Materials of Kentucky. C. H. Richardson. 1925. (Mss.)

Vol. 30.—Topography of Kentucky. W. R. Jillson. 1925. (Mss.)

Vol. 31.—Surface Formations of Northern Kentucky. Frank Leverett. 1925. (Mss.)

Vol. 32.—Pennsylvanian Faunas of Eastern Kentucky. W. C. Morse. 1925. (Mss.)

## Published Reports Sixth Geological Survey (1920-1925)

The record of published reports of the Sixth Kentucky Geological Survey is interesting because of the broad field of investigations covered. Up to the present time the Survey has issued twenty-one separate volumes totaling 5,179 pages. The titles of these reports, some of which are already exhausted in edition, are given in the next table. Following this is presented a tabulation of the pages of the new published geological reports of each of the several State Geological Surveys of Kentucky, from 1838 to 1925.

### BOUND VOLUMES ON KENTUCKY GEOLOGY

| | Year | Vol. No. | No. Pages |
|---|---|---|---|
| 1. Glass Sands of Kentucky—Richardson.. | 1920 | I. | 149 |
| 2. Economic Papers on Kentucky Geology —Jillson | 1921 | II. | 304 |
| 3. Oil Field Stratigraphy of Kentucky— Jillson | 1922 | III. | 738 |
| 4. Geology of the Golconda Quadrangle— Weller | 1921 | IV. | 148 |
| 5. Geology and Coals of Webster County— Glenn | 1922 | V. | 249 |
| 6. The Sixth Geological Survey—Jillson | 1921 | VI. | 291 |
| 7. Mississippian Series of Eastern Ky.— Butts | 1922 | VII. | 188 |
| 8. Clay Deposits of Kentucky—Ries | 1922 | VIII. | 241 |
| 9. Geography of the Jackson Purchase— Davis | 1923 | IX. | 185 |
| 10. Geology of Princeton Quadrangle— Weller | 1923 | X. | 163 |

| | | | |
|---|---|---|---|
| 11. Building Stones of Kentucky—Richardson | 1923 | XI. | 355 |
| 12. Fluorspar Deposits of Kentucky—Currier. | 1923 | XIII. | 189 |
| 13. Surface Waters of Kentucky—King | 1923 | XIV. | 190 |
| 14. Geological Research in Kentucky—Jillson | 1923 | XV. | 228 |
| 15. Wild Life in Kentucky—Funkhouser | 1925 | XVI. | 385 |
| 16. Geography of the Kentucky Mountains—Davis | 1924 | XVIII. | 180 |
| 17. Coal Industry in Kentucky—Jillson | 1924 | XX. | 164 |
| 18. Oil Shales of Kentucky—Thiessen, White, Crouse | 1925 | XXI. | 242 |
| 19. Road Materials of Kentucky—Richardson | 1924 | XXII. | 209 |
| 20. Geography of the Western Coal Field—Burroughs | 1925 | XXIV. | 211 |
| 21. Mineralogy of Kentucky—Richardson | 1925 | XXVII. | 170 |
| Total number of pages | | | 5,179 |

BOUND REPORTS OF THE STATE
GEOLOGICAL SURVEYS OF KENTUCKY
(1838-1925)

| Survey | Period | Duration | Pages New Reports |
|---|---|---|---|
| W. W. Mather | 1838 | 1 year | 39 |
| D. D. Owen | 1854-1860 | 4 years | 2012 |
| N. S. Shaler | 1873-1880 | 7 years | 2886 |
| J. R. Procter | 1880-1892 | 12 years | 1684[6] |
| C. J. Norwood | 1904-1912 | 8 years | 2761 |
| J. B. Hoeing | 1912-1918 | 6 years | 4280 |
| W. R. Jillson | 1918-1925 | 7 years | 6952[7] |

## Topographic Base Mapping

During the past biennium the Kentucky Geological Survey has been unable to enter into a co-operative topographical agreement with the U. S. Geological Survey for quadrangular base mapping in Kentucky, due to the fact that the specific annual appropriation for this purpose of $17,500.00 made by the Legislature in 1924 was vetoed by the Governor. A small amount

[6] During this same time Proctor reprinted 1,336 pages of geological reports prepared by N. S. Shaler.

[7] This figure includes 1,773 pages prepared under the supervision of the present State Geologist and published by the Dept. of Geology and Forestry of Kentucky from 1918-1920.



of money was withdrawn from the general geological fund to complete the Scottsville, Cub Run and Mt. Eden quadrangles, each of which was nearly finished when the funds were withdrawn. 194 square miles of new work was completed on the unfinished Taylorsville quadrangle when the work was stopped down. All of this work was done for publication at the scale 1:62,500 with a contour interval of 20 feet. Some revision was done on the unpublished Cave-in-Rock (Marion, Crittenden County) quadrangle by the U. S. Geological Survey without cost to the Kentucky Geological Survey. The Cub Run quadrangle is now completed and available as an engraved map. The Scottsville has been issued as a preliminary photolithograph and will soon be engraved. The Mt. Eden quadrangle is now in the hands of the engraving department of the U. S. Geological Survey, and will be issued early in 1926. Almost exactly 51% of the area of Kentucky is now topographically base mapped.

If funds are provided for the resumption of topographical base mapping by the legislature during the 1926 session, this work which is now so urgently demanded by many people throughout the state will be reundertaken on July 1, 1926, and advanced as rapidly as possible towards its completion. The opinion of the public and the press with respect to this urgent matter is well reflected in a recent editorial from the Lexington Herald, which follows:

### FOR GEOLOGICAL SURVEY.[8]

"Civic Clubs of Ashland, Louisa, Grayson and Greenup have joined in an effort to have the legislature of Kentucky make an appropriation at its coming session for $50,000 with which to make a geological survey and topographical base maps showing the oil, coal, fire clays, brick clays, shale and other resources of Boyd, Carter, Greenup and Lawrence Counties. Topographical base maps and a geological survey will turn a searchlight upon the buried talents in all the counties where a 'quadrangle' is surveyed. The surveys and mapping will do more.

"Numbers of industries considering locations and dependent upon the existence of certain resources in the vicinity of their plant sites, write to the geological surveys of various states. They ask for information concerning locations. In regard to many counties the Kentucky Geological Survey must write to them, expressing its belief that certain resources are contained, but acknowledging that no survey has been made and admitting, 'this has not been mapped.'

"The industry, of course, then scratches the Kentucky county off its list if it can find what it desires, for instance, in West Vir-

[8] Editorial, Lexington Herald, December 26, 1925.

ginia, which is 100 per cent topographically base mapped, or Ohio, which is 100 per cent topographically base mapped, or Illinois, which is spending $60,000 a year for surveys and mapping.

"The state highway department uses the maps made by the geological survey. If the state does not appropriate funds for these maps to be made by the survey, the highway department will have to spend its income for such maps, which is merely a departmental demonstration of robbing Peter to pay Paul. It is worse, however, in that maps of the highway department would have no value for any other purpose than road construction.

"At present of the 40,598 square miles of Kentucky, only approximately half of the state's area has been mapped. With the exception of the Kenova quadrangle, the northern counties of central and eastern Kentucky, the 'camel's back' on the map of Kentucky, are not base mapped. The federal government will pay half of the cost of the geological surveys and will make the maps."

## Value of Physical Properties

At the request of the State Auditor, the Director of the Kentucky Geological Survey has inventoried the physical properties of this state department and summarized their cost and value. These have been tabulated by groups and total $48,853.00, the investment period as indicated below extending from 1920 to 1925 inclusive, except in the item of library, a portion of which is probably fifty years old.

Estimates of Values and Expenditures for Improvements and Printing, Kentucky Geological Survey, since 1920-1925 inclusive:

| | |
|---|---|
| Office furniture, including typewriters, etc. | $2,330.00 |
| Instruments, field and drafting | 1,775.00 |
| Permanent improvements including stock filing devices, etc. | 2,835.00 |
| Mineral and fossil collections for cabinet | 8,000.00 |
| Reports, maps, publications, etc. | 33,913.00 |
| Kentucky Geol. Survey Library, 6,350 vols., pamphlets and maps[9] | 9,520.00 |
| Total | $58,373.00 |

## Mineral Resource Production

During the last several years mineral resource development has been very active in Kentucky. This has been particularly true in coal, oil, natural gas, fluorspar and rock asphalt. Other materials such as building stones, clays, sands, gravels, etc., have had a slower, though steady, increase. The total annual value of Kentucky's mineral resources and mineral products is estimated to be about $200,000,000.

[9] Number of cloth bound volumes, paper pamphlets and maps is an estimate.



The volume and value of a few of the outstanding minerals of Kentucky is given herewith:

### COAL PRODUCTION IN KENTUCKY.[10]

| | Volume | Value |
|---|---|---|
| 1921 | 30,282,659 tons | $81,460,352.00 |
| 1922 | 42,134,175 tons | 127,037,000.00 |
| 1923 | 43,149,962 tons | 113,542,000.00 |
| 1924 | 43,387,732 tons | 88,745,968.00 |
| Total | | $410,785,320.00 |

### OIL PRODUCTION IN KENTUCKY

| | Volume | Value |
|---|---|---|
| 1921 | 9,080,845 bbls. | $33,556,241.00 |
| 1922 | 8,889,303 bbls. | 17,532,766.00 |
| 1923 | 8,087,250 bbls. | 15,189,916.00 |
| 1924 | 7,437,232 bbls. | 14,418,982.00 |
| Total | | $80,697,905.00 |

### ROCK ASPHALT

| | Tons | Value |
|---|---|---|
| 1923 | 139,401 | $1,115,208.00 |
| 1924 | 245,929 | 1,967,932.00 |
| 1925 | 240,841 | 1,926,928.00 |
| Total | | $5,010,068.00 |

### FLUORSPAR PRODUCTION IN KENTUCKY

| | Volume | Value |
|---|---|---|
| 1921 | 18,670.11 tons | $360,146.42 |
| 1922 | 63,322.20 tons | 1,170,194.25 |
| 1923 | 56,803.34 tons | 1,181,509.47 |
| 1924 | 46,728.07 tons | 965,869.20 |
| Total | | $3,678,719.34 |

### NATURAL GAS PRODUCTION IN KENTUCKY[10]

| | M. Cu. Ft. Volume | Value |
|---|---|---|
| 1921 | 4,820,000 | $1,597,000.00 |
| 1922 | 5,872,000 | 1,879,000.00 |
| Total | | $3,476,000.00 |

[10] From records of the U. S. Geol. Survey.

CLAY PRODUCTION IN KENTUCKY

| | Volume | Value |
|---|---|---|
| 1921 | 35,591 tons | $204,400.00 |
| 1922 | 67,591 tons | 270,858.00 |
| 1923 | 102,195 tons | 428,021.00 |
| Total | | $903,279.00 |

## Hydro-Electric Development.[11]

Active applications for hydro-electric power projects in Kentucky under Federal jurisdiction have greatly increased during the last two years. The following list indicates the activeity in developing this natural resource of Kentucky at the present time. Similar activity is in progress in Tennessee.

289 Name: Louisville Gas & Electric Co.
Address: Louisville, Ky.
Applying for: Preliminary permit.
Project: To develop power at dam No. 41 in Ohio river at Louisville, Ky., which dam the U. S. government proposes to construct, the new dam to have an increased height of about 6 feet.
Proposed Use: Public utility. License issued Nov. 11, 1925.

304 Name: The Winchester Water Works.
Applying for: Preliminary permit.
Project: Develop power at U. S. Lock and Dam No. 10, in Kentucky river, the power to pump water about 4 miles to the company's existing reservoir, supplying water to Winchester. Preliminary permit issued March 4, 1924.
Proposed Use: For pumping domestic water supply.

389 Name: Cumberland Hydro-Electric Company.
Addresss No. 1011 Fletcher Savings & Trust Building, Indianapolis, Indiana.
Address: 1414 Beacon street, Boston, Mass.
Applying for: Preliminary permit.
Project: Three dams and power houses, just above Burnside, Ky., and at Cumberland Falls in Cumberland river, and in the South Fork of Cumberland a short distance above its mouth. Preliminary permit issued March 24, 1924.
Proposed Use: Public utility.

473 Name: Kentucky Northern Power Co.
Address: Frankfort, Kentucky.
Applying for: Preliminary permit.

[11] Data from O. C. Merrill, Ex. Secy. Fed. Power Comm., Washington, D. C., Dec. 15, 1925.



Project: Dam in Licking river about 3 miles above Falmouth.
Proposed Use: Public utility. Preliminary permit issued June 26, 1924.

537 Name: Louisville Hydro-Electric Co.
Address: Louisville, Ky.
Applying for: Preliminary permit.
Project: 100-foot dam in Green river, near Mammoth Cave, Edmonson and Hart counties, Kentucky.
Proposed Use: Public utility. Preliminary permit issued May 29, 1925.

539 Name: Kentucky Hydro-Electric Co.
Address: Louisville, Ky.
Applying for: Preliminary permit.
Project: Power plants at Locks 1-7 inclusive in Kentucky river, in Henry, Owen, Carroll, Franklin, Anderson, Woodford, Mercer, Fayette, Jessamine and Garrard counties, Kentucky.
Proposed Use: Public utility. Preliminary permit issued May 28, 1925.

540 Name: Kentucky Hydro-Electric Co.
Address: Louisville, Ky.
Applying for: Preliminary permit.
Project: Power plants at Locks 8-14 inclusive in Kentucky river in Madison, Jessamine, Clark, Estill and Lee counties, Kentucky.
Proposed Use: Public utility. Pending.

545 Name: Offutt, Loughridge, Gunn & Hifner, Jr.
Address: 205 First and City National Bank Building, Lexington, Ky.
Applying for: Preliminary permit.
Project: Power plant in North Fork of Kentucky river near Airdale, Kentucky, developing about 47,000 horse-power.
Proposed Use: Public utility.

546 Name: Offutt, Loughridge, Gunn & Hifner, Jr.
Address: 205 First and City National Bank Building, Lexington, Ky.
Applying for: Preliminary permit.
Project: Power project at each government dam on Kentucky river known as Locks Nos. 8 to 14, inclusive (from High Bridge to Beattyville).
Proposed Use: Public utility. Pending.

551 Name: Kentucky-Tennessee Light & Power Co.
Address: Bowling Green, Ky.
Applying for: Preliminary permit.
Project: Power plants at government dam in Barren river and Nos. 4, 5 and 6 in Green river, in Warren, Butler and Edmonson counties, Kentucky, developing about 1,349 horse-power.

PROPOSED USE: Public Utility. Preliminary permit issued May 28, 1925.

566 NAME: Kentucky Hydro-Electric Co.
ADDRESS: Louisville, Ky.
APPLYING FOR: Preliminary permit.
PROJECT: 1160-foot dam about one mile above Booneville, with appurtenant power structures, South Fork Kentucky river, Owsley and Clay counties, Kentucky, near Booneville and Manchester.
PROPOSED USE: Public utility. Pending.

604 NAME: Kentucky Hydro-Electric Co.
ADDRESS: Louisville, Ky.
APPLYING FOR: Preliminary permit.
PROJECT: Power development in North Fork of Kentucky river, about one mile upstream from Airdale, in Lee, Wolfe and Breathitt counties, Kentucky.
PROPOSED USE: Public utility. Pending.

613 NAME: Kentucky-Tennessee Light & Power Co.
ADDRESS: Bowling Green, Ky.
APPLYING FOR: Preliminary permit.
PROJECT: Power plant on east bank of Green river, immediately below U. S. Dam No. 1, in Henderson county, Kentucky. The installation will have a primary capacity of 792 horse-power.
PROPOSED USE: Public utility. Pending.

617 NAME: Kentucky-Tennessee Light & Power Co.
ADDRESS: Bowling Green, Ky.
APPLYING FOR: Preliminary permit.
PROJECT: Power development at Locks 2 and 3, Green river, McLean and Muhlenberg counties, Kentucky, (near Henderson and Bowling Green).
PROPOSED USE: Public utility. Pending.

## CONSERVATION

In Kentucky, as in many other Commonwealths in the United States, the natural resources of the land have in some instances been exploited to the evident detriment of the public good. The individual exploitation of the mineral resources of this or any other country is only justified by the continuance or the improvement of the public welfare. Wasteful and destructive mineral operations of any kind, though legal and temporarily productive of substantial individual gain, find nothing in sound public economics to recommend their continuance. Only in times of real national emergency are such operations to be justified.



The wealth of Kentucky as an integral part of the nation is to a very large degree based upon an intelligent, extensive, yet conservative development of all natural and mineral resources. Conservation in this proposal should not, however, be misinterpreted. Conservative development of our resources does not mean long delayed operations, nor does it mean broadly the inhibition of development for one industrial group as contrasted to that of another. It does mean, without any question, the use, and the full use, of all mineral and natural resources for the best interests of the public, both present and future. Irreplaceable mineral existing in a definite, though in many instances an unknown quantity, should not be recklessly exploited and wasted by this generation when it is certain that a growing posterity will certainly have as great or greater need for them. This problem when examined in terms of national welfare involves the fundamentals of the future political dominance and independence of this country among the nations of the world. In view of its great significance it is therefore very important that our coal and iron be mined, that our oil and gas be produced, that our wasting water power be utilized in every way so that the greatest efficiency will be obtained to the end that these resources which are in fact the only guarantee of a continuing progress and prosperity for this state and this nation may be made to last as long as possible.

## OFFICE WORK OF THE SURVEY

The office routine of the Kentucky Geological Survey has been carried forward during the past biennium by a small staff of three regular or full-time employees, including the State Geologist. The statutes do not provide for an Assistant State Geologist, and for this reason the burden of an increasing general correspondence service to the people of the state is carried by the Director of the Survey. During the two-years period covered by this report, a total of 14,264 letters have been received, or an average of twenty-five per day. In reply 11,932 have been sent, giving an average of twenty-two per day. The smaller number of letters sent out as compared to those received is accounted for by the fact that a considerable portion of the correspondence calls for certain reports and maps and does not require other

official reply. A detailed statement by months is given in the following statement:

CORRESPONDENCE THROUGH THE U. S. POSTOFFICE AT FRANKFORT, KY., FOR THE TWO FISCAL YEARS

July 1, 1923 to June 30, 1925, Inclusive.

| Year | Month | Letters Received | | Letters sent | |
|---|---|---|---|---|---|
| 1923 | July | 720 | | 440 | |
| 1923 | August | 608 | | 542 | |
| 1923 | September | 561 | | 387 | |
| 1923 | October | 585 | | 529 | |
| 1923 | November | 633 | | 569 | |
| 1923 | December | 743 | | 676 | |
| 1924 | January | 565 | | 424 | |
| 1924 | February | 619 | | 458 | |
| 1924 | March | 659 | | 420 | |
| 1924 | April | 574 | | 533 | |
| 1924 | May | 549 | | 404 | |
| 1924 | June | 432 | | 357 | |
| Total July 1, 1923 to June 30, 1924, inclusive | | 7,248 | 7,248 | 5,739 | 5,739 |
| Year | Month | Letters Received | | Letters sent | |
| 1924 | July | 559 | | 575 | |
| 1924 | August | 440 | | 434 | |
| 1924 | September | 578 | | 625 | |
| 1924 | October | 704 | | 582 | |
| 1924 | November | 497 | | 320 | |
| 1924 | December | 490 | | 450 | |
| 1925 | January | 615 | | 457 | |
| 1925 | February | 595 | | 572 | |
| 1925 | March | 665 | | 625 | |
| 1925 | April | 558 | | 525 | |
| 1925 | May | 837 | | 678 | |
| 1925 | June | 478 | | 350 | |
| Total July 1, 1924 to June 30, 1925, inclusive | | 7,016 | 7,016 | 6,193 | 6,193 |
| Grand total for the two years ending June 30, 1925 | | | 12,464 | | 11,932 |
| Daily average | | | 25 | | 22 |

One of the chief activities of the Kentucky Geological Survey is the furnishing of detailed and accurate geological and scientific information concerning the geology, mineral and natural resources of Kentucky. In this state and international service during the past biennial period 23,087 geological reports and maps, an average of 40 per day, have been sent from this office in response to written or personal requests accompanied by separate amounts of postage as required by law as shown by the following statement:



KENTUCKY GEOLOGICAL SURVEY PUBLICATIONS DISTRIBUTED BY REQUEST

July 1, 1923 to June 30, 1925, Inclusive.

| Year | Mo. | No. Mailed | Carried Away | Total | |
|---|---|---|---|---|---|
| 1923 | July | 721 | 97 | 818 | |
| 1923 | Aug. | 279 | 128 | 407 | |
| 1923 | Sept. | 309 | 137 | 448 | |
| 1923 | Oct. | 417 | 129 | 546 | |
| 1923 | Nov. | 320 | 68 | 388 | |
| 1923 | Dec. | 425 | 140 | 565 | |
| 1924 | Jan. | 580 | 131 | 711 | |
| 1924 | Feb. | 1,130 | 748 | 1,878 | |
| 1924 | Mar. | 587 | 282 | 869 | |
| 1924 | Apr. | 798 | 43 | 841 | |
| 1924 | May | 883 | 80 | 963 | |
| 1924 | June | 821 | 143 | 964 | |
| Total for Fiscal Year 1923-1924 | | | | 9,398 | 9,398 |
| (Fiscal Year 1924-1925) | | | | | |
| Year | Mo. | No. Mailed | Carried Away | Total | |
| 1924 | July | 1,396 | 175 | 1,571 | |
| 1924 | Aug. | 646 | 126 | 772 | |
| 1924 | Sept | 956 | 1,137 | 2,093 | |
| 1924 | Oct. | 1,222 | 127 | 1,349 | |
| 1924 | Nov. | 921 | 42 | 963 | |
| 1924 | Dec. | 710 | 72 | 782 | |
| 1925 | Jan. | 1,001 | 258 | 1,259 | |
| 1925 | Feb. | 890 | 120 | 1,010 | |
| 1925 | Mar. | 714 | 115 | 829 | |
| 1925 | Apr. | 860 | 165 | 1,025 | |
| 1925 | May | 1,019 | 290 | 1,309 | |
| 1925 | June | 610 | 117 | 727 | |
| Total for Fiscal Year 1924-1925 | | | | 13,689 | 13,689 |
| Grand total for two fiscal years | | | | | 23,087 |
| Daily average | | | | | 40 |

The reports and maps distributed as indicated above pertain to every subject relative to the geology, soils and mineral resources of Kentucky. These publications have been sent, not only to every place in Kentucky, but throughout the United States; also Canada, Mexico, England, France, Germany, Japan and China. Request for publications of the Kentucky Geological Survey through foreign libraries, industrial corporations and institutions is a growing one. The total amount of postage received in this service was re-used directly during the past biennium and has amounted to $1,559.78. Since this amount of postage thus obtained is in effect, a revolving unit being used as quickly as it is taken in, amounts in excess of a few dollars are never maintained in the office of the Survey. Of all the considerable amount of business which has proceeded through the U. S. post office for first-class correspondence and second-class mail or publications, not one penny has been drawn from the treasury of the state of Kentucky. In this respect the Kentucky Geological Survey is entirely self-supporting. The monthly and annual totals of postage received by the Kentucky Geological Survey follows:

RECEIPTS FOR POSTAGE FOR BIENNIUM

FIRST FISCAL YEAR

July 1, 1923 to June 30, 1924, inclusive.

| | | | |
|---|---|---|---|
| 1923 | July | $66.00 | |
| | August | 40.00 | |
| | September | 43.00 | |
| | October | 64.30 | |
| | November | 41.50 | |
| | December | 81.80 | |
| 1924 | January | 64.70 | |
| | February | 34.80 | |
| | March | 38.00 | |
| | April | 60.00 | |
| | May | 39.00 | |
| | June | 25.00 | |
| | Total | $598.10 | $598.10 |

SECOND FISCAL YEAR

July 1, 1924 to June 30, 1925, inclusive.

| | | | |
|---|---|---|---|
| | July | $61.00 | |
| | August | 45.00 | |
| | September | 19.00 | |



| | | | |
|---|---|---|---|
| | October | 95.00 | |
| | November | 50.00 | |
| | December | 64.00 | |
| 1925 | January | 47.40 | |
| | February | 35.00 | |
| | March | 55.00 | |
| | April | 55.00 | |
| | May | 120.00 | |
| | June | 30.00 | |
| | Total | $676.40 | $676.40 |

| | |
|---|---|
| Grand total used in mailing parcel post packages, special delivery and registrations | $1,274.50 |
| Letters mailed the first fiscal year, 7248, at 2c | 144.96 |
| Letters mailed the second fiscal year, 7016, at 2c | 140.32 |
| Total postage used during the two fiscal years, 1923-1925 | $1,559.78 |

## RECOMMENDATIONS TO THE GOVERNOR AND LEGISLATURE

The natural wealth of Kentucky naturally falls into two major divisions: (1) Used wealth, and (2) unused wealth. Included in the broad classification of used wealth is found the productive agriculture, mineral and natural resources of this Commonwealth. The greater part of the unused or potential wealth of Kentucky at the present time exists in the form of undeveloped and to a large degree unknown mineral and natural resources. These resources are widely distributed throughout the state from the Big Sandy to the Mississippi river. Trite as it may seem, it is certainly a fact that practically every county of Kentucky has in it at the present time resources of one kind or another which have not been fully examined, prospected or developed. In some of the counties these undeveloped and unproductive resources are of vast extent.

The progress and prosperity of Kentucky are directly dependent upon the fullest utilization of the natural and mineral resources of this state, combined with general manufacturing industry. Agriculture, due to a combination of fortuitous and systematic circumstances, has been developed to a rather high point in Kentucky, particularly in the Bluegrass region, and in the western part of the state. Industrialization, slow in getting

a foothold in this state because of the pronounced disinterest in manufacturing, has within the last decade or two shown undeniable increase both in volume and diversification, particularly in that portion of Kentucky which adjoins the Ohio river. While during this same period a considerable amount of mineral resource development has gone forward in Kentucky, especially in the high grade bituminous and coking coal sections of Southeastern Kentucky, it is a lamentable fact that many mineral resources in this state are today unworked and undeveloped, due to the fact that little is known concerning their location, their quality or their quantity.

It is the function of the Kentucky Geological Survey to investigate for the people of the state as a whole the various mineral resources of this state, and to map them and their associated geology. This the Survey has been engaged in doing for a number of years, but up until recently has been severely handicapped because of the lack of sufficient funds with which to operate. Another drawback has been the lack of accurate topographical base maps on which detailed geology might be delineated. One of these obstacles was overcome at the last (1924) session of the legislature, when there was appropriated for the investigation of the mineral resources of Kentucky and their associated rocks, the sum of $40,000.00 in two separate appropriations.

Much of this money, in accordance with the governing act, has been spent during the past biennium in the investigation of high class road materials such as rock asphalt, limestone, sandstone and cement materials, including clays. This work has now progressed to a point where it is indicated that much good may accrue to this state and a considerable saving to the taxpayers in the construction of roads if these investigations, which are now under way but incomplete, can be continued. It is therefore recommended that the general appropriation of $40,000.00 for general geological purposes be continued throughout the next biennium.

During the last two years little, if any, progress has been made in the work of topographical base mapping in Kentucky, due to the fact that through error the biennial budget appropriation of $17,500.00 was vetoed in March, 1924. As a result of this veto the Kentucky Geological Survey has not been able to continue its comprehensive program of co-operative base mapping

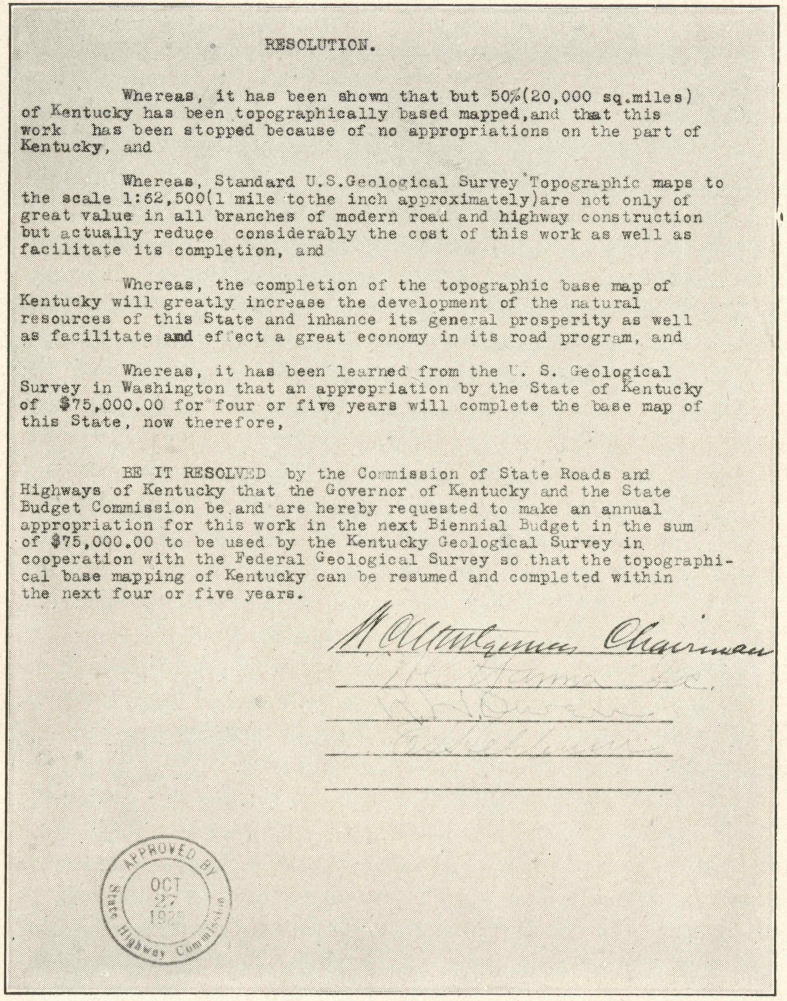


with the U. S. Geological Survey, Topographic Branch, an arrangement which had been in effect for many years previous to 1924.

The suspension of topographical base mapping has been severely felt by many lines of individual, corporation, state, county, municipal and departmental work. Operators of mineral properties have called for maps for undeveloped areas which might have been surveyed at this time had the money been available. Corporations looking to extensive operation of their undeveloped holdings have been hampered in their work of expansion on account of lack of maps for areas which are unsurveyed. The Kentucky State Department of Roads and Highways has repeatedly requested quadrangular topographic maps for unmapped areas which it has been impossible to supply. The lack of these maps has seriously impeded all branches of state and county road work in the field. In many instances inability to supply these maps has actually diverted proposed mineral development and investment from Kentucky into states adjoining, such as Ohio and West Virginia, Commonwealths which are entirely (100%) base mapped topographically.

The seriousness of the continuance of this condition in Kentucky is apparent. The loss of new wealth and added prosperity to this state because of retarding influences of unmapped and unknown areas can hardly be estimated, but must be very large. On July 1, 1925, of the 40,598 square miles comprising Kentucky, 20,723 square miles, or a little over 50%, was actually base mapped topographically. At this time 19,875 square miles remain unmapped. The urgency of mapping this state has recently reached such proportions as to arouse entire sections of Kentucky to the point where active steps looking towards the completion of such base maps for restricted areas of a few counties in each case have been taken. Recent instances of such action have been found among the business men of Northeastern Kentucky who have organized themselves for the purpose of securing a new topographic base map of Greenup, Carter, Boyd, and Lawrence Counties to the scale of 1:62,500.

Civic action looking towards a similar base map has been taken in Nelson and Bullit Counties, and requests for similar maps have come from unmapped areas in McCreary, Whitley, Clinton, McCracken, Calloway, Montgomery, Menifee, Rowan,



RESOLUTION.

Whereas, it has been shown that but 50%(20,000 sq.miles) of Kentucky has been topographically based mapped,and that this work has been stopped because of no appropriations on the part of Kentucky, and

Whereas, Standard U.S.Geological Survey Topographic maps to the scale 1:62,500(1 mile tothe inch approximately)are not only of great value in all branches of modern road and highway construction but actually reduce considerably the cost of this work as well as facilitate its completion, and

Whereas, the completion of the topographic base map of Kentucky will greatly increase the development of the natural resources of this State and inhance its general prosperity as well as facilitate and effect a great economy in its road program, and

Whereas, it has been learned from the U. S. Geological Survey in Washington that an appropriation by the State of Kentucky of $75,000.00 for four or five years will complete the base map of this State, now therefore,

BE IT RESOLVED by the Commission of State Roads and Highways of Kentucky that the Governor of Kentucky and the State Budget Commission be and are hereby requested to make an annual appropriation for this work in the next Biennial Budget in the sum of $75,000.00 to be used by the Kentucky Geological Survey in cooperation with the Federal Geological Survey so that the topographical base mapping of Kentucky can be resumed and completed within the next four or five years.

W. C. Montgomery Chairman

APPROVED BY State Highway Commission OCT 27 1925

Resolution of State Highway Commission Relative to Co-operative Topographical Mapping.

Letcher, Bell, Bracken and many other counties. The State Highway Commission, sensing the importance of these topographical maps, and realizing that the ultimate cost of mapping to the Commonwealth might be very greatly reduced through their use coupled with a discontinuance of the present duplication of effort and public expenditure, prepared and forwarded October 27, 1925, the following resolution to the Governor:



RESOLUTION

Whereas, it has been shown that but 50% (20,000 sq. miles) of Kentucky has been topographically base mapped, and that this work has been stopped because of no appropriations on the part of Kentucky, and

Whereas, Standard U. S. Geological Survey Topographic maps to the scale 1:62,500 (1 mile to the inch approximately) are not only of great value in all branches of modern road and highway construction, but actually reduce considerably the cost of this work as well as facilitate its completion, and

Whereas, the completion of the topographic base map of Kentucky will greatly increase the development of the natural resources of this State and enhance its general prosperity as well as facilitate and effect a great economy in its road program, and

Whereas, it has been learned from the U. S. Geological Survey in Washington that an appropriation by the State of Kentucky of $75,000.00 for four or five years will complete the base map of this State, now, therefore,

Be it Resolved by the Commission of State Roads and Highways of Kentucky that the Governor of Kentucky and the State Budget Commission be and are hereby requested to make an annual appropriation for this work in the next Biennial Budget in the sum of $75,000.00 to be used by the Kentucky Geological Survey in cooperation with the Federal Geological Survey so that the topographical base mapping of Kentucky can be resumed and completed within the next four or five years.

W. C. MONTGOMERY, chairman
W. C. HANNA, Secretary
R. W. OWEN,
E. S. HELBURN.

SEAL
Approved by
State Highway Commission,
October 27, 1925.

In view of the present circumstances in which Kentucky finds itself with respect to its base mapping program, it is recommended that the sum of $75,000.00 per annum be appropriated during the next biennium for topographical base mapping in co-operation with the U. S. Geological Survey. The Federal Survey has indicated that in accordance with congressional enactment, it will be willing to cooperate on a dollar for dollar basis with the Kentucky Geological Survey, if any reasonable

sum is provided. The mapping work can be started during the coming field season, and if appropriations are made as indicated above the entire topographical base map of Kentucky can be completed within the next four or five years, after which these appropriations will be unnecessary and should properly cease.

## Available Maps and Reports

There are now ready and available for immediate distribution through the Kentucky Geological Survey to any interested individual, corporation, company or institution requesting same a large number of special reports and maps, prepared by this and previous Surveys. These publications cover the general geology and development of many of the mineral resources of Kentucky. The early reports of the 1st and 2nd Geological Surveys (Owen, Shaler and Procter) are now entirely exhausted. The publications of subsequent surveys, including the present or (Sixth) Kentucky Geological Survey, which are now available are listed in chronological sequence by titles and authors. The required postal charge and the number which are still available are indicated. The number of cloth bound reports now in stock is 8,023. The total number of paper bound pamphlets in stock relative to geology is 4,713. The total number of maps is 57,775. The total number of maps and reports now available for distribution is 70,511. A request for any of these publications addressed to the Director, when accompanied by the required amount of postage in stamps (checks or money orders may be used) will be promptly filled until the edition is exhausted. The list given is essentially a duplicate of the one used in the official correspondence of the Kentucky Geological Survey.

## LIST OF AVAILABLE MAPS AND REPORTS

January 1, 1926.

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| Vol. 1, Pt. 2.—Fire Clays of Northeast Kentucky. Technology of Kentucky Clays, Coals of Upper Licking River, Coals of North Fork of Kentucky River, Oolitic Limestones of Warren Co., Asphalt Rock, Soil Surveys, Manufacture of Coke, Elevation and Astronomical Stations. 1913 | 50 | 229 |
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| Relief Map of Kentucky. G. H. Renshawe. 1924 | 25 | 2,700 |
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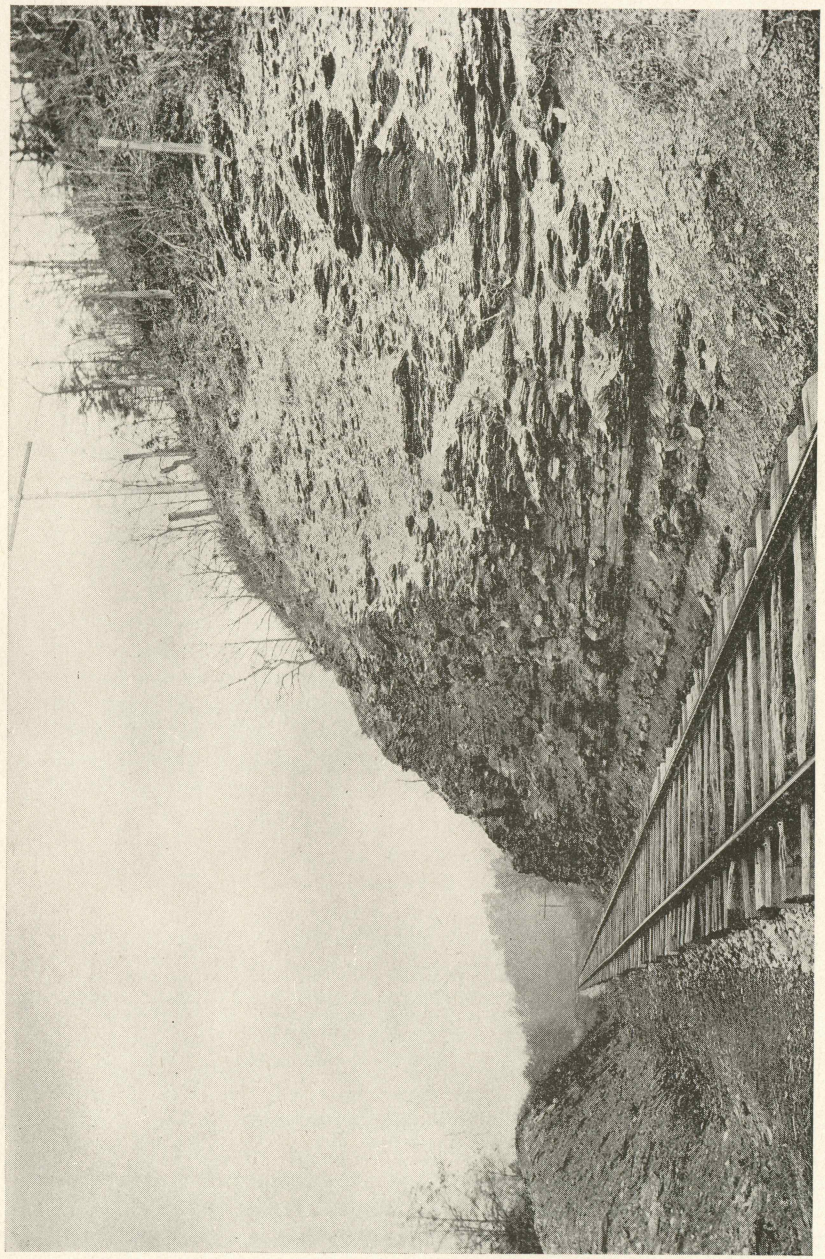

PHOTO BY W. R. JILLSON

OUTCROP OF DEVONIAN OIL SHALE

Much work both in the field and in the laboratory has been done on the oil shales of Kentucky by the Kentucky Geological Survey during the past two years. The deposits of this shale in Kentucky are very large and broadly distributed. The outcrop shown here is located 3 miles west of Clay City in Powell Co., Ky.



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| Map Packet, 1913, contains the following: Coal Mine Map—Upper Licking Valley, Coal Mine Map—Pond and Blackberry Creeks—Pike County, Economic Industries Map of Boyd, Carter and Greenup Counties, Economic Industries Map of a Portion of Rowan County, Coal Mine Maps, 1, 2, 3, and 4 of the Upper Big Sandy Valley, Geology of the Georgetown Quadrangle | 30 | 250 |
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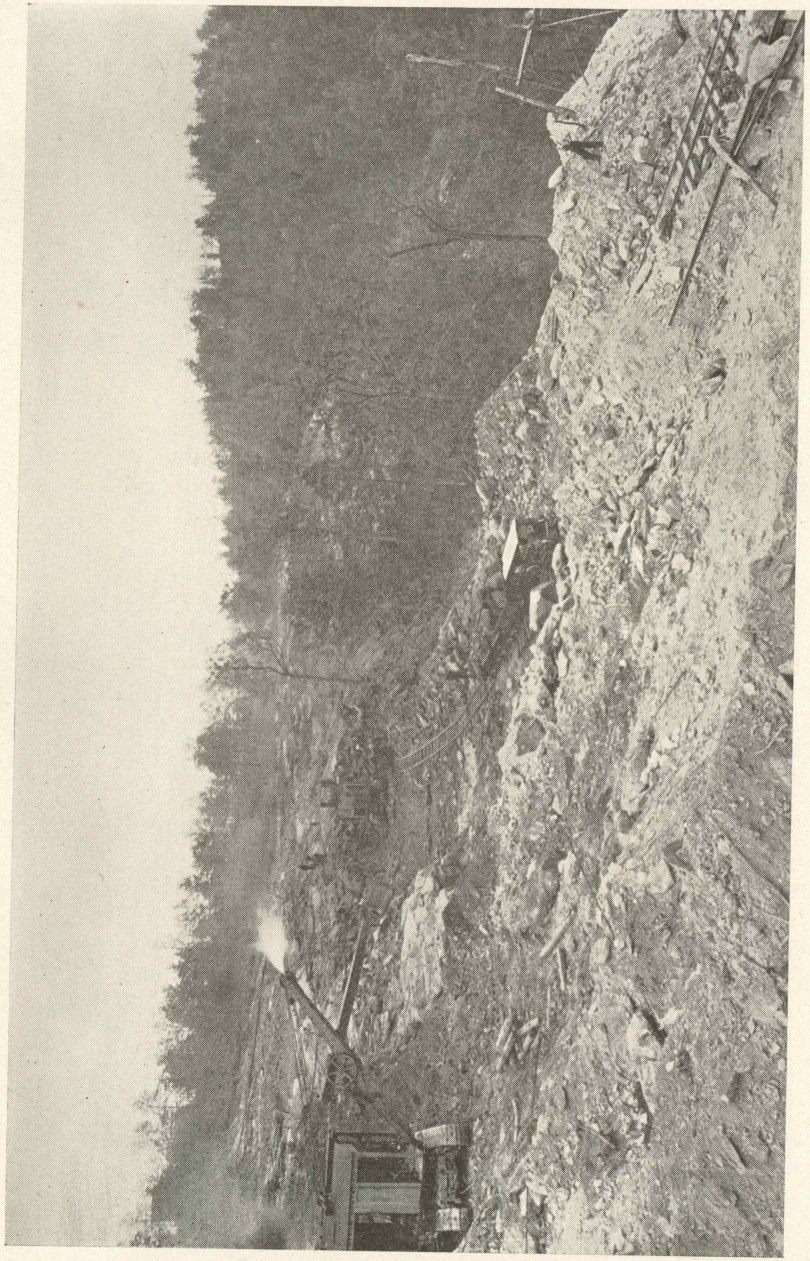

PHOTO BY W. R. JILLSON

ROCK ASPHALT QUARRY, EDMONSON COUNTY, KY.

A notable expansion of the rock asphalt industry in Kentucky has taken place during the last two years, due to a growing national demand for the product in surfacing high type roads. This quarry on the waters of Bear Creek in Edmonson County is one of six active operations in Kentucky. Others are to be found in Grayson, Hardin and Breckinridge Counties, Ky.



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| 33. | Jonesville Quadrangle, parts of Letcher, Leslie and Harlan Counties, Ky.; Lee County, Va., and Claiborne and Hancock Counties, Tenn. | 3 |
| 34. | Kenova Quadrangle, parts of Greenup, Boyd, Carter, Lawrence and Elliott | 5 |
| 35. | Kosmosdale Quadrangle, parts of Jefferson and Bullitt Counties | 20 |
| 36. | Leitchfield Quadrangle, parts of Grayson, Edmonson and Butler Counties, Ky. | 500 |
| 37. | Little Muddy Quadrangle, parts of Butler and Warren Counties | 12 |
| 38. | Lockport Quadrangle, parts of Owen, Henry, Shelby and Franklin Counties | 15 |
| 39. | London Quadrangle, parts of Rockcastle, Pulaski, Jackson and Laurel Counties | 16 |
| 40. | Louisville Quadrangle, parts of Jefferson and Bullitt Cos. | 30 |
| 41. | Madisonville Quadrangle, parts of Hopkins, Muhlenberg and McLean Counties | 24 |

| | | Copies in Stock |
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| 42. | Mammoth Cave Quadrangle, parts of Edmonson, Barren, Warren and Hart | 450 |
| 43. | Manchester Quadrangle, parts of Jackson, Owsley, Clay, Leslie, Laurel, Perry, Breathitt and Knox | 4 |
| 44. | Mattewan Quadrangle, parts of Pike County, Ky.; Mingo and Logan Cos., W. Va. | 35 |
| 45. | Monticello Quadrangle, parts of Wayne, Russell and Pulaski Counties | 25 |
| 46. | Morganfield Quadrangle, parts of Union and Webster Cos. | 35 |
| 47. | Mt. Eden, parts of Shelby, Anderson and Franklin Counties, Kentucky | 25 |
| 48. | Naugatuck Quadrangle, parts of Martin and Lawrence Cos. | 20 |
| 49. | Newburg Quadrangle, parts of Henderson and Daviess Counties | 24 |
| 50. | New Haven Quadrangle, part of Union County | 50 |
| 51. | Nolansburg Quadrangle, parts of Harlan County, Ky., and Lee County, Va. | 15 |
| 52. | Nortonville Quadrangle, parts of Hopkins, Muhlenberg and Christian Counties | 18 |
| 53. | Owensboro Quadrangle, part of Daviess County | 25 |
| 54. | Paintsville Quadrangle, parts of Lawrence, Johnson, Morgan and Magoffin Cos. | 14 |
| 55. | Pikeville Quadrangle, parts of Pike and Floyd Counties | 12 |
| 56. | Pound Quadrangle, parts of Pike and Letcher Counties | 18 |
| 57. | Princeton Quadrangle, parts of Caldwell and Lyon Cos. | 20 |
| 58. | Prestonsburg Quadrangle, parts of Johnson, Floyd and Magoffin Counties | 24 |
| 59. | Prospect Quadrangle, parts of Jefferson and Oldham Cos. | 25 |
| 60. | Providence Quad., parts of Crittenden, Union, Webster, Caldwell and Hopkins Counties | 25 |
| 61. | Regina Quadrangle, parts of Pike County, Ky.; Dickenson and Buchanan Cos., Va. | 20 |
| 62. | Richmond Quadrangle, parts of Jessamine, Fayette, Madison, Estill, Jackson and Garrard Counties | 2 |
| 63. | Salyersville Quadrangle, parts of Menifee, Morgan, Wolfe, Magoffin and Breathitt Counties | 5 |
| 64. | Scottsville Quadrangle, parts of Allen, Barren and Warren Counties, Kentucky | 20 |
| 65. | Sebree Quadrangle, parts of Henderson and Webster Cos. | 45 |
| 66. | Shawneetown Quadrangle, parts of Union and Crittenden Cos., Ky.; Hardin and Gallatin Cos., Ill. | 20 |
| 67. | Spring Lick, parts of Ohio, Butler and Grayson Counties | 450 |
| 68. | Sutherland Quadrangle, parts of Daviess, McLean and Ohio Counties | 30 |



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| 69. | Taylorsville and LaGrange Quadrangle, parts of Jefferson, Bullitt, Spencer, Shelby and Oldham Counties | 25 |
| 70. | Tell City Quadrangle, Parts of Hancock and Daviess Cos. | 15 |
| 71. | Troublesome Quadrangle, parts of Perry, Breathitt and Knott Counties | 10 |
| 72. | Uniontown Quadrangle, parts of Union and Henderson Counties | 20 |
| 73. | Whitesburg Quadrangle, parts of Letcher and Knott Cos. | 12 |
| 74. | Whitesville Quadrangle, parts of Daviess, Hancock and Ohio Counties | 13 |
| 75. | Williamsburg Quadrangle, parts of McCreary, Whitley, Pulaski, Laurel, Knox and Bell Counties, Kentucky, and Scott, Campbell, Claiborne Counties, Tennessee | 15 |
| 76. | Williamson Quadrangle, parts of Pike and Martin Counties, Ky.; and part of Mingo Co., W. Va. | 12 |
| | Total topographical quadrangular maps | 3,698 |
| | Grand total all maps | 57,775 |
| | Grand total of all reports, papers and maps | 70,511 |

## Addendum

The fundamental importance of the work of the Kentucky Geological Survey in mapping and detailing the geology and mineral resources of this Commonwealth, so generally recognized throughout the state, has been specifically recognized by Governor William J. Fields. Recently in his official biennial message delivered in person before the General Assembly of Kentucky, on January 6, 1926, the Governor made the following important statement relative to the development of the mineral wealth of Kentucky. Late publication of this administrative report of the Survey allows its inclusion here in addendum:

### Mineral Resources and Base Mapping[12]

"Kentucky, with its more than forty thousand square miles, is richly endowed with natural and mineral wealth. Coal, iron, gas, potters' clay, flint fire clay, mineral waters, rock asphalt, fluorspar, and many other minerals abound. Although the state's mineral resources are now only about 25% developed, their value within recent years has attained the annual figure of about $200,000,000.00. At the present time 51% of the area of Kentucky is topographically base mapped. The fact that nearly

one-half of this state is unmapped is the direct cause of annually diverting many millions of dollars of investment from Kentucky into such adjoining states as Ohio, West Virginia, and others, which are one hundred per cent base mapped at the present time.

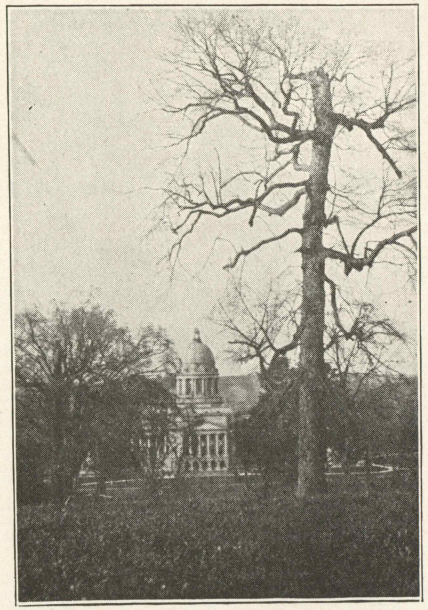
"In order to build up industry, increase invested capital, facilitate highway construction, and produce a more widespread and lasting prosperity, Kentucky needs to complete at once her topographical base map. For this purpose an appropriation of $75,000.00 annually for the next biennium is recommended, to be used by the Kentucky Geological Survey in dollar for dollar cooperation with the United States Geological Survey, in a comprehensive program, which will early complete this needed mapping inventory of the states' area and mineral wealth. At the same time the present annual appropriation of $40,000.00 for geological investigation of road materials and other important mineral resources should be maintained."

[12] Biennial Message of Governor W. J. Fields before the General Assembly of Kentucky, Jan. 6, p. 55, Frankfort, Ky. 1926.

# XVI.

## STATE PARKS IN KENTUCKY*

Within the last decade or two a new national movement has been developing in the United States. It has had as its main objective the establishment of large public recreational areas now commonly known as State Parks. This movement



THE CAPITOL AT FRANKFORT

originated in the federal policy of setting aside for public use large primeval tracts in the western country. These areas have come to be known as National Parks. They enjoy a wide and favorable reputation. In practically all cases they were established as units from much larger blocks of public lands and are to be

* Ky. Geol. Survey, Series VI, Pamp. VI, 14 p., 1926. Anniversary Address, Perryville Battlefield, Perryville, Ky., Oct., 1925. Reprinted from 26th Biennial Report of the Ky. Dept. of Agriculture, Labor and Statistics. 1925. At the time this paper was written the author was Chairman of the Kentucky State Park Commission, as well as State Geologist of Kentucky.

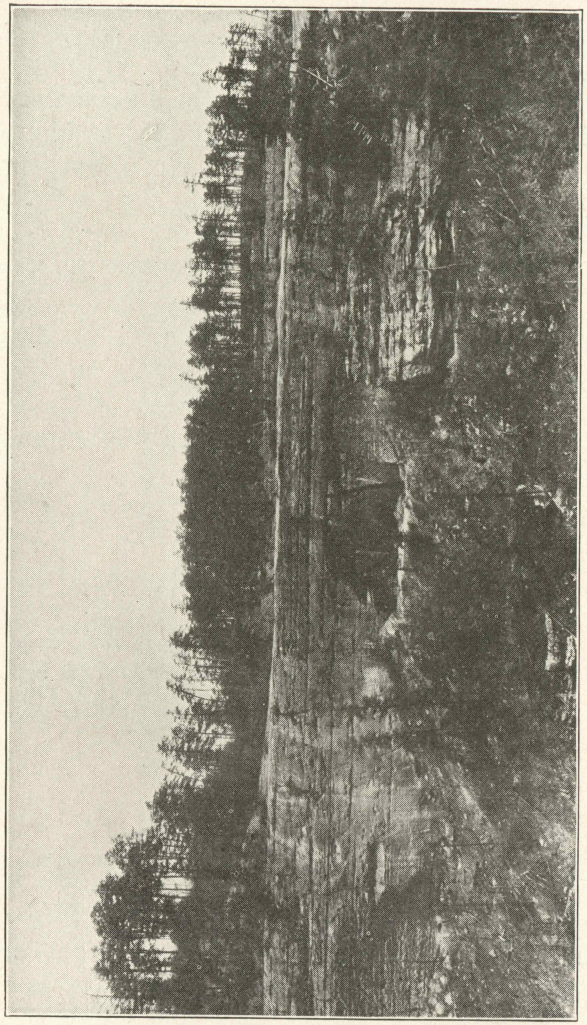


PHOTO BY W. R. JILLSON

NATURAL BRIDGE

Few natural bridges in the Eastern United States possess the stately dignity of this splendid Eastern Kentucky sandstone structure. Its structural characteristic is more that of the great natural rock arches of the Rocky Mountains and the great West than those of the Appalachians.



kept in their natural condition, with such improvements of roads and housing conditions as may be necessary, for all time.

### In Progress Fifty Years

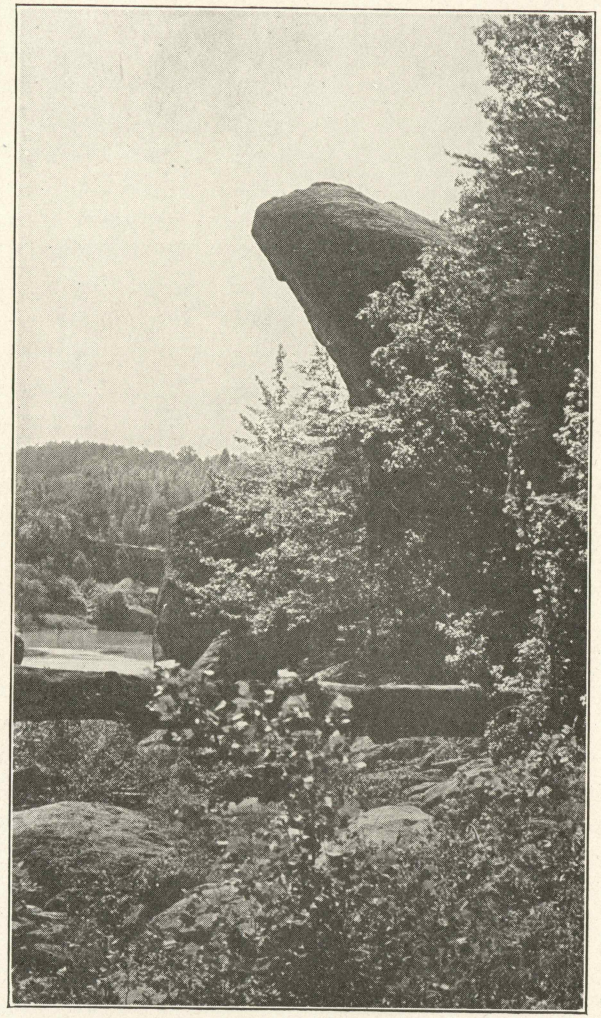
In the west the matter of national park establishment has been in progress more than half a century. It has not been difficult of attainment since the lands did not have to be purchased from private ownership. Public opinion now indicates that it was a wise policy which directed the establishment of these national parks and national forests, one which combined the best principles of conservation and public interest.

In the densely populated East, however, where practically all the land has been taken up for several generations, where timber has been cut and farming areas pushed back into the headwaters of the most remote mountain regions, it was not possible a quarter of a century ago to interest the public in the establishment of large park areas. As a result there has been up until recently only one national park in the eastern United States, although there are several federal forests which, for the most part, have been of rather late acquisition.

Up until the year 1900 the average American citizen apparently thought little and cared less about public parks in the eastern United States. He knew that the beauties of the high Rockies, the Sierras, and the Coast Ranges could only be found in the far west. In the scramble to tour the Yellowstone, the Yosemite and the Colorado Gorge, sight was lost of the many gems of landscape in the East, where if admittedly built on a smaller scale the beauties of nature are none the less real and satisfying.

### Motors Bring Realization

About this time an event occurred which was destined to revolutionize public opinion in regard to public parks. With the construction of the automobile attention was at once directed to the need of recreational areas within easy reach of the densely populated urban and agricultural districts in the eastern United States. The problem was not easy of solution, but with the strong will of all the people behind it, ways and means were



BOULDER IN CUMBERLAND GORGE
There is much in the Gorge of the Cumberland River to fascinate the eye of the nature lover. Giant rocks tilted and overturned by a capricious river abound.



found, curiously enough, for the establishment of large public parks even in the most congested districts.

An instance of this is seen in the Palisades Interstate Park of New York and New Jersey. At the same time the good roads movement had its birth, and the two going hand in hand have now reached proportions of the first order throughout the united States.

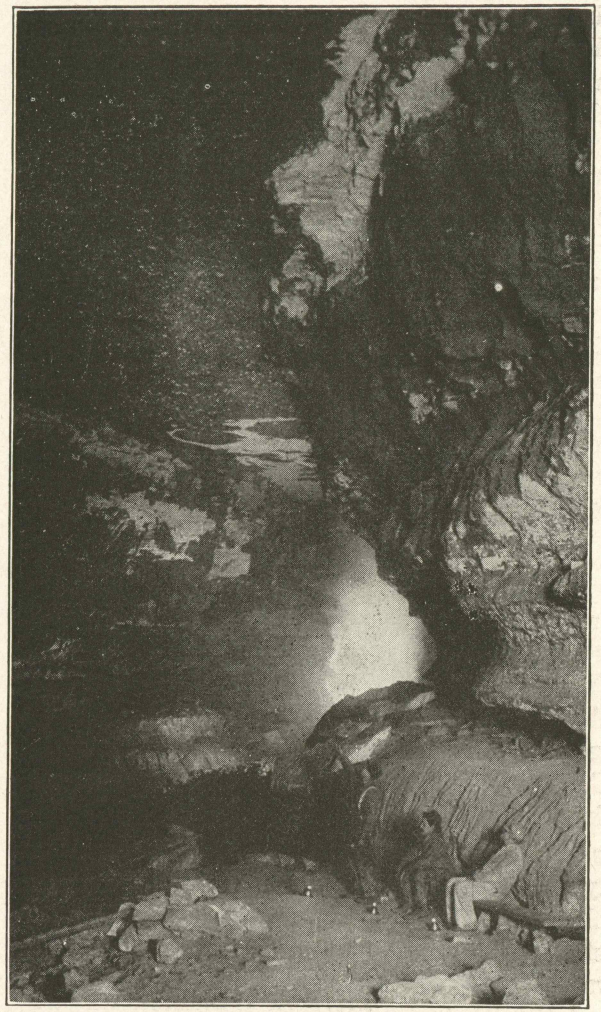
In Kentucky, as elsewhere, though more recently, the construction of high type through automobile roads developed the necessity for a large number of public recreational objectives—State Parks. Fortunately, in this state the per capita population is relatively sma'l and though practically all of the land is held as individual or corporation property, much of it, due to the topographical figure of the landscape, has been but slightly changed from the original condition. This is particularly true of the rough mountain sections where important minerals are known not to occur. It is also true of a number of somewhat more restricted areas elsewhere in this state.

### Nature Sculptures Wonders

Nature in following out her physical processes has sulptured out ridge and meander and subterranean stream. In all of the limestone regions of Kentucky, caves, caverns and rock houses abound. Some of these caverns, such as the group surrounding Mammoth Cave of Edmonson County and those of Carter County, have come to have not only a national, but an international reputation.

It is indeed fortunate that many of the natural beauties of Kentucky are still available, for in this state the movement for the establishment of parks, like that for the completion of a statewide system of high type roadways, has been slow in getting under way. Up until 1924, when the legislature of this state established the Kentucky State Park Commission, no definite plan had been adopted looking forward to the creation of public recreational areas adequate to meet the rapidly growing needs of our population.

It is true that at Frankfort the grounds surrounding the old and new Capitol buildings are in the nature of a state park, and it can be said with certain satisfaction that the establishment



THE STAR CHAMBER

Of the many visual treats in the Mammoth Cave none attracts more attention than the Star Chamber. Thousands speculate on this unique phenomenon annually.



of the "Old Kentucky Home" at Bardstown as a state shrine possesses features similar to those incorporated in some State Park programmes. Yet neither of these possesses fully the features now so urgently demanded by the public, though each has its special attractions and is annually visited by many thousands of people.

An adequate State Park program for Kentucky should embody, first, a careful examination of all unusual natural areas; second, a review of all areas identified in an important way with the State and national history; third, a selection of certain regional tracts that embody the best ideals of State Parks established elsewhere, and fourth, a well directed effort, both private and public, to acquire some of the selected areas by gift of deed for actual use by the public as State Parks.

The Commission named by the last legislature has attempted to follow such a program. Shortly after its organization a survey of the state was made, and areas suitable for State Parks were indicated. Among these were the Breaks of Sandy, the Cumberland Gap, the Cumberland Falls, the Carter Caves, the Kentucky River Gorge, the Mammoth Cave, Reelfoot Lake and others, including such historical places as the old fort at Boonesboro and Harrodsburg. The Blue Licks Battlefield on the Licking River is also recommended and should receive early favorable consideration.

### Pine Mountain First

The response throughout the state was immediate and genuine. The first definite offer came from Pineville in the form of a large block of land on Pine Mountain and Clear Creek. Deeds were drawn and accepted by the Commission for the proposed Cumberland State Park. Rapidly following came other offers of gift of deed to tracts suitably located at Harrodsburg and Elkton. These have also been approved.

Recently the Louisville & Nashville Railroad offered to the Commonwealth its fully developed park at Natural Bridge. This matter will receive final consideration at an early date. A number of other gifts of land have been offered in both eastern and western Kentucky which are now receiving consideration.

Among these is the Perryville battlefield, already a state reservation. On this ground, hallowed by the blood of hundreds

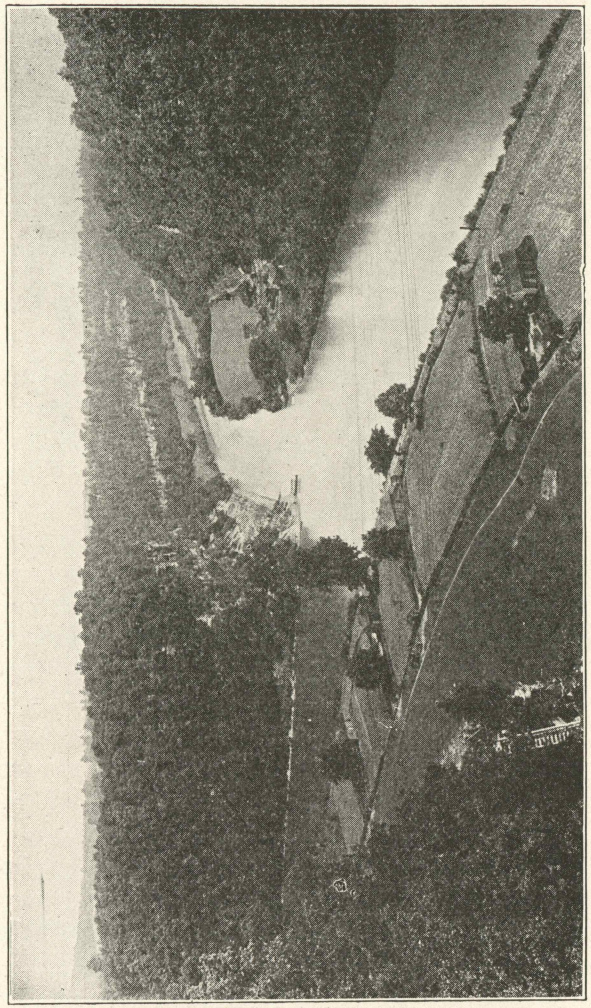


PHOTO BY W. R. JILLSON

MEETING OF THE WATERS

A splendid view showing the gorge of the Kentucky River (left) at the mouth of the Dix River. The latter stream has recently been dammed for hydro-electric power.



of loyal Kentuckians, we are gathered in a great anniversary service. Here was fought in 1862 the most sanguine engagement of the state. It was in large measure the Gettysburg of the west. It decided important issues of the western campaign and definitely altered the course of the Civil War.

Where now are the armies of Bragg and of Buell, the host in blue, and the regiments in gray? Gone, gone forever from this sunny slope, most of them to join the encampment of the heroic dead. Others returned to their home lands and their loved ones far from this scene of fratricidal strife stand at this time reminiscent as the sun of life drops low.

### Memory of Pioneers

In all her progress in field and stream and city, Kentucky, the first child of the Golden West, must not forget the men who made her great. The pioneer, the Indian fighter, the soldier of '61, each in turn deserves a lasting memorial from the hand of an appreciative Commonwealth.

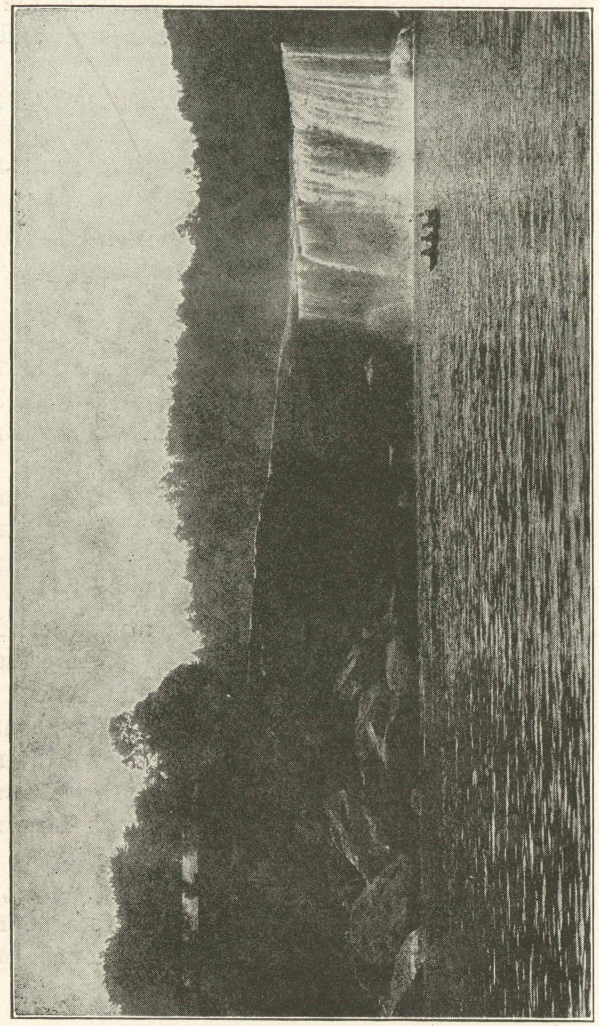
There is a place in Kentucky's state park program for the Perryville battlefield. Certainly no part of this Commonwealth typifies more thoroughly all of the hope and despair and heroism that marked this great struggle of American arms.

In the peace and prosperity of a great country reunited and fulfilling a world destiny under the principles of democracy, it is nothing less than a civic duty that directs our footsteps here.

This battlefield should become well known throughout our country wherever American history is repeated, wherever the starry flag is flown. It should rank with Gettysburg, Lookout Mountain and Vicksburg. Kentuckians with souls heroic and hearts aflame have sanctified this ground for the ages. Kentuckians, now in thoughtful mood, may tread these paths, and, mindful of the glorious past these graves bespeak, feel the inspiration to a higher idealism, a better and a truer Americanism.

"The muffled drum's sad roll has beat
The soldier's last tatoo.
No more on life's parade shall meet
That brave and fallen few;
On Fame's eternal camping ground
Their silent tents are spread,
And Glory guards, with solemn round,
The bivouac of the dead."

O'HARA



CUMBERLAND FALLS

A beauty spot in every sense of the word. Kentuckians should know more about and value more highly this majestic waterfall. It presents every attribute of a well chosen state park. The pity is that it is not one already. This great falls also possesses hydro-electric power values of a high order.

# XVII.

## NATURAL RESOURCES OF KENTUCKY*

Kentucky stands at the threshold of a new day—a day in which public interest is to turn as never before to internal industrial development. Imbued with this belief we are gathered here to discuss problems of primary importance to corporate advancement and public welfare. Public utilities are conceded to be the arteries of modern life. Through them flows the intercourse of the people, social and commercial. In addition to unrestricted and rapid communication, they provide the necessities of life; power, light, and materials moving through them from their frequently remote sources to the point of ultimate consumption.

Highly developed and efficient public utilities, successful in their separate fields of endeavor, widely ramifying throughout the Commonwealth, bespeak ease of personal and corporate contact, heightened standards of living, and wide regional prosperity. The successful operation of all kinds of public utilities, however, is predicated upon the efficient and widespread development of all the basic natural resources of the land—agriculture, forestry, mining, and hydro-electric power. Any state which neglects the development of one or more of these inherent resources, fails in that same measure to take advantage of its fullest opportunities.

With these considerations in mind it is appropriate now at the beginning of the second quarter of the twentieth century, that we thoughtfully review the recent progress of economic development in Kentucky. Once apprised of its present status and trend, we may cast ahead into the future with a firmer grasp and understanding of the obstacles which must be overcome before general conditions so universally desired can be attained. Twenty-five years ago Kentucky was essentially an agricultural state. From the waters of the Big Sandy westward to the Mississippi, and from the Ohio shore to the Tennessee line, through-

* Kentucky Outlook, pp. 4-5, Lexington, Ky., Feb. 13, 1926. Address before ninth annual meeting of the Kentucky Association of Public Utilities, January 15, 1926, at the Brown Hotel, Louisville, Ky.

out the broad extent of more than forty thousand square miles of a great Commonwealth, the tradition of the land centered about the agriculture of the Bluegrass and the Pennyroyal, and the timber of the Mountains.

Little was known at this time in the industrial north concerning the mineral resources of Kentucky. Middlesboro in the shadow of the Cumberlands had been a failure as had Grand Rivers on the lower waters of the Tennesse. Kentucky's oil production was about 60,000 barrels, and her entire coal output was less than 5½ million tons. The greatest coal mining section of the State centered about Hopkins and Muhlenberg Counties for at this time the headwater extension of the mountain railroads of Eastern Kentucky had not been built. All of that rich and thriving industrial section now so well known in Southeastern Kentucky was essentially an undeveloped wilderness. In this mountainous region the land, however, had been taken up and occupied in one way or another for several generations. Social and living conditions were becoming less and less attractive, however, due to the gradual impoverishment of the thin mountain soil.

In the years which followed leading up to the time of the world war capital seeking investment in response to the growing demand of a teeming industry in the north gradually found its way into Kentucky, particularly Eastern Kentucky. Properties were taken up, railroads were surveyed and built, mines were opened, oil and gas wells were drilled, pipe lines were laid. Quietly but with strong purpose the sleeping giant of industrialism in Southeastern Kentucky awoke and became filled with a purpose entirely new to this State, while central and western Kentucky continued the even tenor of their way more or less unmindful of the great changes which were taking place in the mineral regions of the Commonwealth. The highly mineralized sections rapidly came to the front, pauper counties became self-supporting, new and modern schools and roads were built and a flow of wealth and prosperity heretofore unknown in these sections become plainly evident.

As if by some Aladdin-like touch the mineral wealth of Kentucky leaped forward in volume and in value until within recent years the stupendous prospect of it has become more or less generally apparent. Awakening within the last few years



Kentucky has found her crude minerals and mineral products leaving this State in an annual volume of something like $200,000,000. At the same time the population of this State has remained almost stationary as compared to that of the growth of the adjoining and Eastern States. With an average population of about thirty-seven to the square mile, her internal structure is pitifully weak, and over all hardly self-supporting. It has been discovered that the agricultural sections of Kentucky, which from the days of the explorer Daniel Boone were the burden bearer of the Commonwealth, were inherently weak.

Recently it has become apparent that the richest areas in point of actual productive and potential wealth are the mineralized sections of the State. It is from these sections that the greatest development of liquid and real estate wealth is to be expected. Population growth will naturally come in these regions. Their progress, social and economic, is inevitable. The areas producing rock asphalt, coal, oil, natural gas, fluorspar, building stones, flint fire clays and fire clays, and pottery clays in commercial quantity and quality are the hope of the new Kentucky. Throughout these broad regions a widespread system of drainage allows of a large development of cheap water power, the volume of which will be measured eventually in thousands of Killowatt hours per day. It is the key to a new and far reaching industrialism.

As the prospect of this new industrialized Kentucky looms broadly upon the horizon of this State, just at a time when it is so sorely needed to sustain the political and social fabric of the Commonwealth, it is again apparent that something is lacking to flux our potential development. A close investigation of the present situation leads to the opinion that two important elements are in reality needed to bring about a more rapid extension of internal expansion in Kentucky. One of these is a detailed inventory and description of the natural and mineral resources of this State based upon accurate topographical maps, the same to be widely circulated. This the Kentucky Geological Survey can do if adequate funds are provided by the legislature in the budget.

The second missing factor is a centralized and broadly informing state publicity body. This body would function effectively in distributing accurate information relative to all of the

natural resources and regional opportunities found in Kentucky. Such a body has elsewhere been called a State Chamber of Commerce or Publicity Commission. It is not at all improbable that the present session of the Legislature will seek to create such a body in response to the requests of certain non-partisan civic bodies. Given the erection of such a commission and granting for it an intelligent and harmonious function coupled and coordinated with all other branches of the State and municipal government, Kentucky will be free to go forward because of her inherent wealth, as few in this State have ever had the vision to perceive.

Up to the time of the world war, the great migrations of the United States were westward following the climates of nativity. The tide is now turning. With a lessened expansion in the west due to loss of opportunity there, the overflow of population from the Atlantic seaboard will, in the next 25 years, flow south. This indeed it has already begun to do into Florida, Alabama, and Texas in what is probably one of the greatest migrations in the history of the American people. Kentucky stands in a geographic position close to the center of population of the United States between the cotton fields, the corn belt, and coal and iron deposits. If she will but throw off a devitalizing sectionalism and the fetish of many wornout and unproductive traditions, and address herself earnestly to a redeeming and inevitable industry, the year 1950, well within the expectation of many who are gathered here today, will see this Commonwealth as rich, as prosperous and as splendid as any in the United States.

# XVIII.

## UNUSED NATURAL WEALTH—AN OPPORTUNITY*

The future of any social or political enterprise is advanced or retarded by the operation of immutable economic laws. In this respect State and National affairs are much the same as are the smaller items of a corporation or an individual. Geographic position, climatic features, prevalency of unconquerable disease, useful natural and mineral resources coupled with the basic intelligence of a race, are the principal operative factors. In most instances, these factors are involved in complex relations which are often of difficult interpretation. Marked social, economic, and intellectual advancement or retardation of every political group hinges upon their combined directive influence. Unfortunately this fact, as well as the fundamental nature of the factors themselves, is frequently but poorly understood by the general public.

Since, however, the operation of economic laws is not delayed one tittle by ignorance, all progressive citizens should find an abiding interest in their interpretation as applied to local conditions. In a day that is plainly characterized by a rapid shifting from the old to the new, it is nothing less than the duty of every intelligent citizen of Kentucky to address his mind to the large problems which confront this Commonwealth, and seek in his own way their solution.

The present is intimately bound up with the past. Any interpretation of present conditions in Kentucky looking toward the betterment of the public welfare must take into consideration not only the social and economic institutions of today, but must compare them with those of the recent past. In such a way the trend of social and economic development can be seen, and with it some prospect for the future. The earliest considerable industry associated with the territory now known as Kentucky was hunting and trapping. This, in turn, was followed by pioneering agriculture. Hunting required a very great virgin territory for the support of a very few individuals. Early

* The Kentucky Outlook, pp. 4-6, Lexington, Ky., Feb. 27, 1926. Presented before the Louisville Kiwanis Club, Wednesday noon, February 10th, 1926, at the Kentucky Hotel, Louisville, Kentucky.

domestic or pioneering agriculture certainly required less area per capita than did hunting, but individual boundaries were still very large. On the other hand, social contact was slight and living conveniences few indeed.

As the American nation grew the demand for timber in the northeast increased rapidly and soon penetrated this State. Timber cutting came to the front during the middle part of the 19th century as one of the greatest industries of Kentucky. A choice heavily timbered hard and soft wood region was soon cut over. The devastation eliminated the hunter. It advanced agriculture in certain sections to some extent, produced more arable and pasture land, and resulted in a period of agricultural dominance. It also gave a false sense of security.

In the Northern states of this Union the year 1840 marked the close of a similar pageant. The period from 1817 to 1835 saw the development of canals connecting the Atlantic seaboard and the interior through Pennsylvania, New York, Ohio, Maryland and other states. Then followed the construction and a partial consolidation of the first short line railroads from 1830 to 1850, and with these improvements in transportation Northeastern America became an intricately diversified industrial and technical region. The development of industry gave rise to much manufacture for the interior. It supplied a growing river traffic, much of which served Kentucky and the Southwest. This river traffic expanded from 128 tons of new construction in 1815 to 1250 tons in 1851. During the same period and up to the present time the Great Lakes transportation increased many thousand per cent.

Kentucky situated just to the south and west of this great and growing industrial region was easy of access and source for many of the crude materials needed. Beginning, in a small way, with iron and salt, this state rapidly turned national producer of coal, oil, natural gas and many other necessary mineral products. A study of the various operations shows that they were opened and operated in most cases to supply industrial demands elsewhere. A review of the early industrial conditions in Kentucky shows that relatively few of the enterprises either producing or consuming large amounts of minerals in Kentucky were either organized by native Kentuckians or owned by them.



While the exploitation of Kentucky mineral has gone rapidly forward within recent years it is still plain that the bulk of the citizenship in Kentucky is not interested either in owning or operating industries which have to do with the production or utilization of the State mineral or natural resources. Agriculture, including stock raising, improved or provincial, and timbering, now almost a vestige, are still the principal vocations of the state. Manufacturing and the new industrialism of the Great Lakes and Atlantic seaboard have made slight if any progress in Kentucky, except in a few favored localities in the Ohio River lowlands, notably at Paducah, Owensboro, Louisville, Covington, Newport, and Ashland.

While prosperity continues to increase in Ohio, New York, Pennsylvania, West Virginia and many adjoining States where problems of taxation are easily solved and economic trends are upward rather than stationary or downward, Kentucky continues to be treading a hesitant course as measured by all factors of social and political advancement. Antiquated, worn out and inadequate detentional, corrective, and educational institutions vie with a depressed agriculture in decrying the trend of the times. It must be apparent that something is basically wrong. This defect is to be found in the economics of Kentucky rather than in its politics, popular opinion to the contrary notwithstanding, for it is a truism that politics and government rest upon economic institutions. It is the business of good government to protect and foster sound economic conditions, and these in turn will insure continued good government.

Unsound or inadequate economics never yet supported a satisfactory government for any length of time. The national blunder of ante-bellum times was government ownership, and the lesson learned by the American people was costly but a very important one. The Federal government and the governments of the States, with one or two notable exceptions, are no longer directing their energies along the lines of government operation of large enterprises. Private ownership, based upon individual profits and the rendition of actual services to the ultimate consumer, has become one of the unwritten laws of the land.

In this evolutionary process, the individual and cottage worker has given away before factory industry based upon power generated through natural and mineral sources and accompanied

by the intelligent use of accurate and standardized tools. Organization, competition, credit, and specialization have all combined to produce an intricate industrialism which separates us as a nation, completely from the civilization of a hundred years ago. The progress of each American Commonwealth in the sisterhood of States is now measured by its industrialism or organized modern agriculture. Steam, gas, and hydro-electric power, cheap at any price when compared to man or animal power, determines now and will forever determine to what degree any people will participate in the life enriching advantages of the present time.

Kentucky as a hunting state needed no roads or other improvements; as a domestic agricultural and lumbering state needed very few roads or other social advantages. The timber was moved down a God-given intricate system of inland waterways for which this State is well known. A very light tonnage of agricultural products was produced for export. But the Kentucky of today and tomorrow has new desires. It wants and wants badly a connecting system of through and county-seat high type surface roadways, many more modern consolidated school houses, a greater State University, new penal and charitable institutions, and all of the modern conveniences of light, power, and sanitation in the rural as well as urban districts. These things are found nowhere in the world except as the direct or indirect product of industrialism. They represent the almost unlimited conversion of cheap power and natural resources. Any state to enjoy them must have some source of wealth other than a static agriculture and flagging timber industry.

The progress of Kentucky is, therefore, plainly bound up in the development of its mineral and natural resource wealth of all kinds, and the founding upon this natural wealth of a large resident manufacturing industry. The science of applied geology is the key to the new—the coming era. To know the location, the quantity and quality of this wealth, Kentucky must spend energy and money, carefully systematizing and grouping the natural resources of large areas for a number of years. Economic geologists and topographers should comb the hills and vales of every unmapped county of this Commonwealth. Accurate computations indicate that 51 per cent. of this State is at the present time accurately base mapped topographically. Forty-



nine per cent. is unmapped in any accurate way, and in this broad territory the resources, mineral and natural, if they are not entirely unknown are but loosely indexed. At the same time sister States, Ohio, West Virginia, and others with similar natural resources, terrain, and topography are 100 per cent. mapped to the modern scale of 1:62,500 or about one inch to the mile.

No corporation or individual could hope to succeed today in the face of great competition with the utilization of only about 51 per cent. of its resources. Kentucky cannot hope to obtain easily the costly, yet desirable, advantages of a modern State until it obeys the fundamental economic law of a full and efficient utilization of its latent resources. The wealth of Kentucky is founded upon its recreating agriculture and its productive and undeveloped natural and mineral resources. These sources produce diversified occupations of one kind or another, by which life for our entire population is supplied. Insofar as we neglect their development, we are losing step in the progress of the sisterhood of states. And there is some certain danger that according to the law of atrophy the lost step may become what is infinitely worse—permanent.

Kentucky needs to arouse herself to a critical situation. Definite and well directed action should be taken to invite invested wealth into its borders. Mines and quarries need to be opened. More clay and rock asphalt pits should be operated. Hydro-electric power plants need to be built. Invested real wealth of this character will entail additional investments of all kinds in local enterprise and produce permanent payrolls. This means in turn a larger producing and purchasing power, and new sources of State, county, and municipal assessment bringing tax relief. A larger purchasing power is only another way of expressing a broader and richer life for the entire citizenship with lower governmental burdens on all individuals.

No state can hope to escape the legitimate cost of government and public improvements. Good roads, good schools, modern institutions for the unfortunate, an adequate system of State Parks, well equipped courts and many other public necessities for a state as large as Kentucky call for immense sums of annual revenue. Public moneys sufficiently large to create these things and maintain them against rapid depreciation must have a source

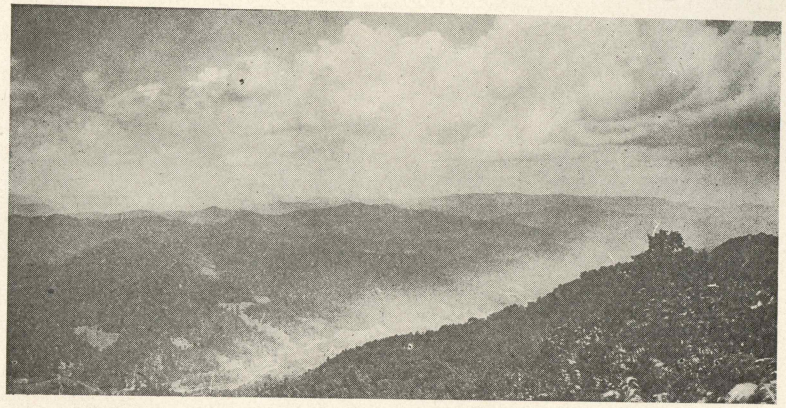
in sound economics and a growing prosperity. Nothing more than a large investment and development of mines, minerals and manufacturing will produce such a prosperity in this State.

Lastly in the list of many annual losses sustained by an impoverished Kentucky, is that of her young citizenship. Young men growing to manhood in our small towns find here no suitable occupation with which to carry on. Adventuresome and ambitious we lose in their departure the best and most competent new blood of our State. The tide goes annually to the North, Northwest and Southwest, leaving the defectives and incorrigibles with us for incarceration and maintenance. It is one of the most lamentable features of the present day. Civic organizations such as the Louisville Kiwanis Club may well direct their serious thought to the sound economic problems which govern the advancement or retardation of every Commonwealth and political group. Kentucky cannot go forward unless these laws are analyzed, and in this highly technical and specialized age. followed with the greatest care and intelligence.

# XIX.

## MAJOR DRAINAGE MODIFICATIONS OF BIG SANDY RIVER*

The Big Sandy River of southwestern Virginia, West Virginia, and eastern Kentucky is only the upper middle portion of a former much larger stream. Recent discoveries of many erratic, stream-worn, quartzite boulders, some of which carry pronounced worm-borings, have been made on the upper waters of the Licking River and the middle waters of the Big Sandy River. These boulders ranging in weight from two to one hun-



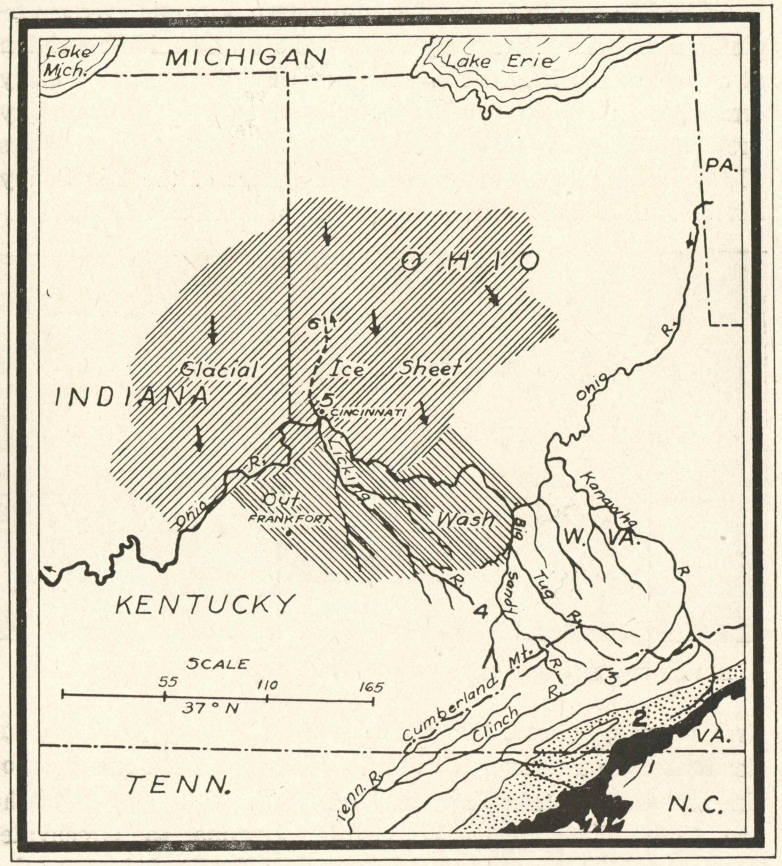
BIG SANDY IN CUMBERLAND PLATEAU NEAR PINE MOUNTAIN

dred pounds, indicate that the ancient Big Sandy River had its headwaters in the Roan Mountain region of western North Carolina and southwestern Virginia. It is in this section of the southern Appalachians, from Wytheville, Virginia, to Greenville, Tennessee, that the parent ledges of Middle Cambric quartzite (Hesse and Erwin formations) occur from which these old stream-boulders were derived. This inference is further substantiated by many specimens of erratic vein and milky quartz found at the same levels and in the same region as the quartzite boulders. Both are apparently identified with the old Cretacic

* Pan-American Geologist, Vol. XLVI, pp. 49-51, Aug., 1926. Paper read before the Kentucky Academy of Science, May 5, 1925.

peneplain, the present summit levels of this part of eastern Kentucky.

Headwater piracy of the Clinch and the Bluestone rivers operating advantageously along northeast and southwest lines of favorable structure, beheaded, probably during Mid Tertic



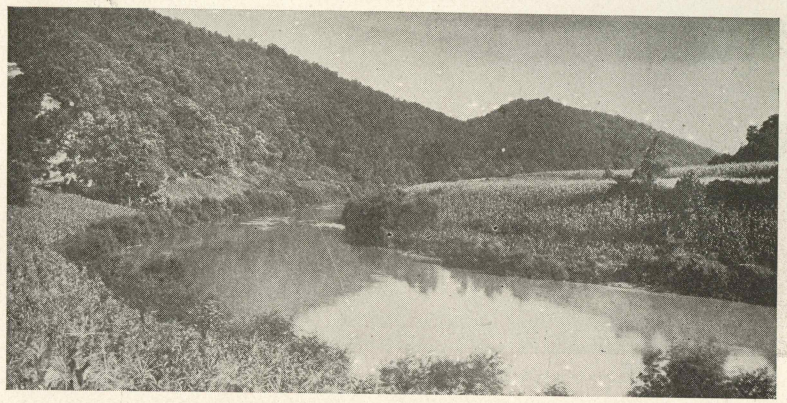

PAST AND PRESENT BIG SANDY DRAINAGE AREAS

times the upper one-fifth of the original Big Sandy River. The occurrence of so many of these quartzite boulders close to levels of the old Cretacic peneplain on the upper waters of the Licking River, as well as adjacent drainage courses, indicates that the Big Sandy River was through-flowing over the Licking to the



northwest as late as the Cretacic period. The probability is that it had occupied this course since the uplift which marked the close of the Paleozoic era. Subsequent structural elevation along the nearly north and south axis of the Paint Creek uplift, in Johnson County, has operated to bisect the waters of the original Big Sandy, and shunted the upper waters to the northeast to join the Tug Fork, the course occupied today.

At the time the Big Sandy River flowed in the course of the Licking River it did not, however, join the Ohio River in the vicinity of the present townsite of Cincinnati, for during the



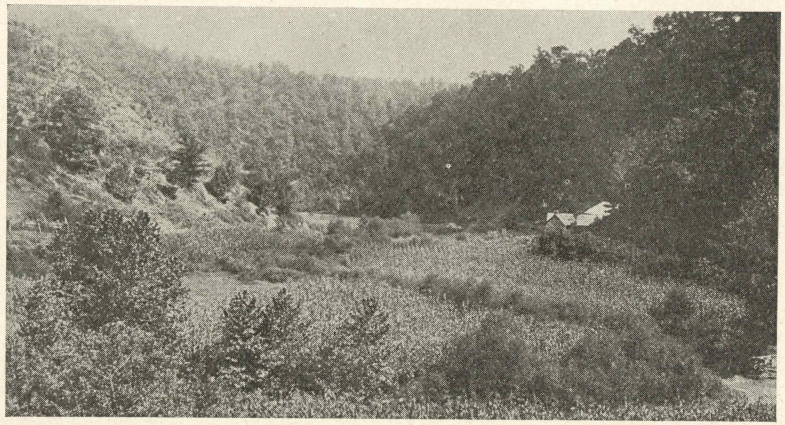
MIDDLE BIG SANDY NEAR PRESTONSBURG

Cretacic period there was no Ohio River, this stream being one of the direct products of Pleistocene glaciation. The original Big Sandy River, therefore, probably flowed on to the northwest in the region of southwestern Ohio and southeastern Indiana until it met major drainage and was turned to the southwest to the Gulf of Mexico, then heading at Cairo, Illinois, or what is more likely to have been the case, to the Great Lakes basin, by way of Lake Erie.

The old Big Sandy basin has thus been cut transversely three times: Firstly, about 75 miles below its headwaters by the Clinch and Bluestone rivers; secondly, 150 miles below its headwaters by the Paint Creek uplift; and thirdly, 300 miles below its headwaters by the newly formed glacial Ohio River. That all of these modifications occurred at the same time is highly im-

probable, but that they are all of post-Cretacic dates is quite certain. Various indications point to the Early and Mid Tertic periods, and Early Quaternic time.

In the accompanying sketch map, 1 is the Roan Mountain, in Tennessee and North Carolina, with Pre-Cambrian, undifferentiated, igneous rocks shown in black and white. 2, is a belt of Mid Cambric quartzites (Hesse and Erwin formation) exhibiting characteristic Scolithus borings. The original headwaters of the



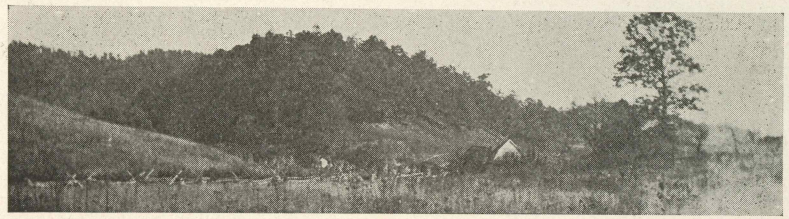
UPPER LICKING RIVER NEAR GRASSY CREEK

Big Sandy River was developed in the central part of areas indicated by 1 and 2 slightly northeast of Roan Mountain. 3, is an area of widespread regional piracy by the Clinch (to the southwest) and the Bluestone River (to the northeast) of the original headwaters region of the Big Sandy River. 4, is a region of diversion of the middle waters of the Big Sandy River by the north and south, Paint Creek uplift, post-Cretacic, resulting the creation of Licking River. 5, is an area of diversion to the southwest in the course of the present Ohio River of original Early Pleistocene times. 6, is the general direction of course of original Big Sandy-Licking River in pre-Pleistocene time. The continuation of this course to the north is unrevealed beneath a heavy mantle of Glacial deposits.

# XX.

## THE ASHLAND GAS FIELD*

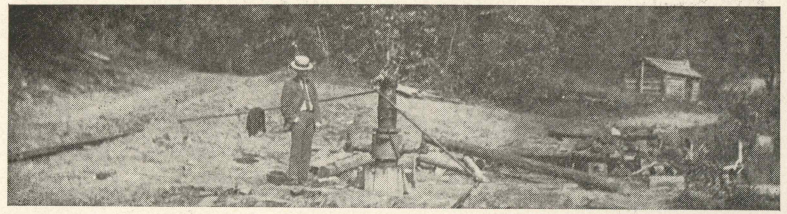
Although Boyd County is the smallest subdivision of eastern Kentucky, it occupies a very strategic geographical position at the juncture of the Big Sandy and Ohio rivers. Ashland, its principal city, with a population of about 26,000 souls (1926)



TYPICAL TOPOGRAPHY OF LOW ROUNDED HILLS

is a rapidly growing iron, fire-brick, and manufacturing center using large amounts of industrial natural gas.

The surface rocks of this region consist of shales, sandstones, coals and limestones given in the order of their importance in the geological section. Stratigraphically these sediments belong to the Pottsville and Allegheny divisions of the Coal

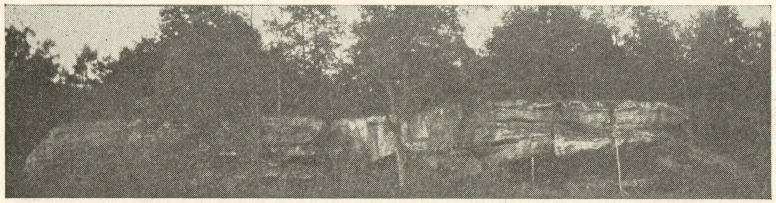


SALT SAND GASSER, 3,500,000 CUBIC FEET

Measures. Structurally, Boyd County exhibits a sweeping monocline dipping to the southeast as measured on a broad surface bed, the Fire-Clay coal at the rate of about 35 feet to the mile. This general structure is interrupted by few pronounced irreg-

* Pan-American Geologist, Vol. XLVI, pp. 121-122, Sept., 1926. Paper presented before the Kentucky Academy of Science, May, 1925. (Oil Domes of Ashland.)

ularities. These structures are: (1) Midland Trail dome, (2) Laurel dome, (3) Four Mile Creek dome, (4) Ashland anticline, (5) Laurel anticline, and, (6) East Fork anticline. The domes are small. The anticlines are of the finger-type, plunging to the southeast. The subsurface structure has recently been given in detail on the Sunbury black shale. It erases the surface domes



CROSS-BEDDED MAHONING SANDSTONE; CONEMAUGH

and smaller features entirely, and increases the dip to the southeast because of the thickening of many beds in this direction.

Nine oil and gas "sands" are recognized, these being in descending order, 1st Salt sand, 2nd Salt sand, and 3rd Salt sand; Big Injun gas sand, Berea Oil and Gas sands, Gordon and Ashland gas sands (3 in number) and the Corniferous limestones (Devonic). The Ohio shales contain three separate Gordon and

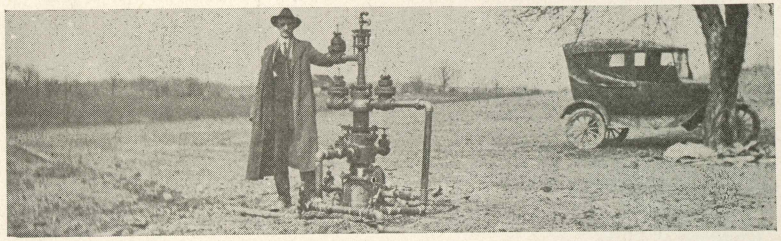
OLD PRODUCING GAS WELL, ASHLAND DISTRICT

Ashland gas sands, all of which are of commercial importance. Beneath the Corniferous horizon, a long sequence of limestones and calcareous shales spans the entire Siluric and Ordovicic sections to depths of at least 4,000 feet. Included in these lower rocks are the "Clinton sand" and "Trenton sand" which here are thought to be unproductive. The Gordon and Ashland gas sands are lenticular and very irregular.

Drilling was first undertaken in Boyd County during the



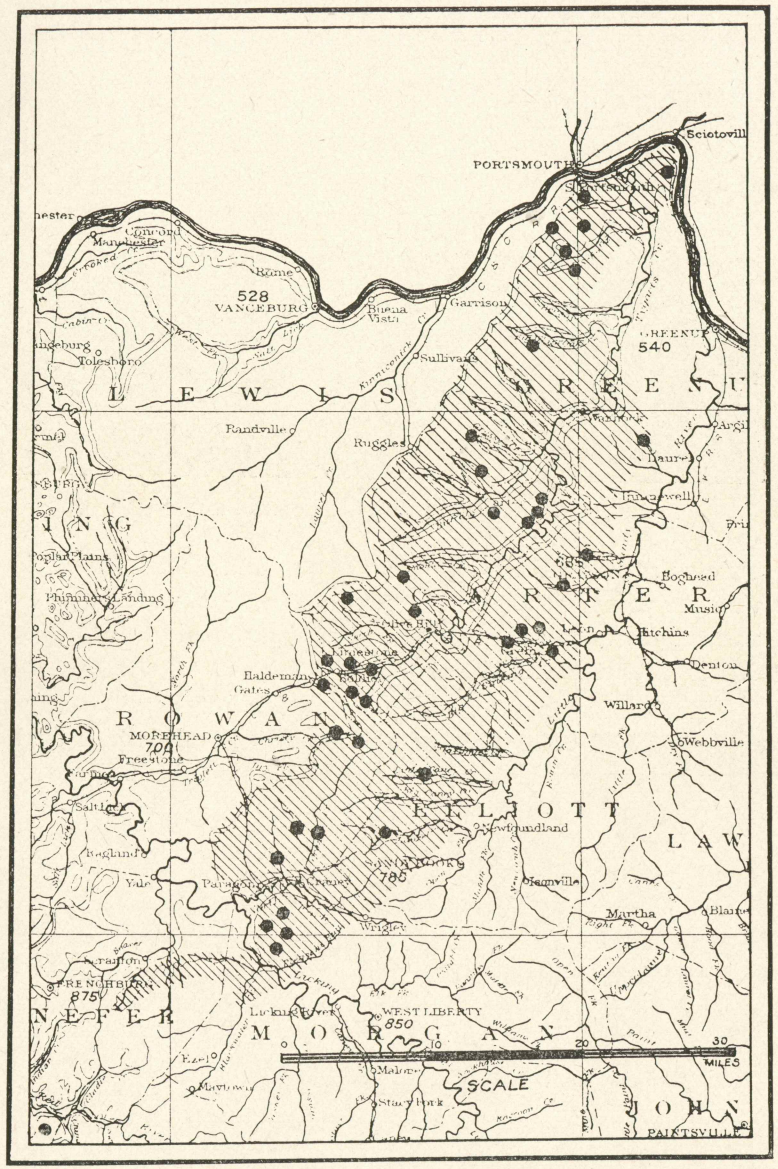
decade 1880-1890 and was carried forward sporadically until 1919, when a considerable body of gas was developed in the vicinity of Ashland for industrial purposes. Successful natural gas drilling is in progress at the present time. A total of about 80 wells have been drilled in Boyd County. This prospecting indicates that oil from the Berea and Corniferous formations may be developed in small commercial quantities, particularly in the



"BIG INJUN," "BEREA," AND OHIO SHALE GAS

vicinity of Bolts Fork, Summit Station, and Laurel Creek, but that the principal commercial production of this county will be natural gas varying in volume from 200,000 cubic feet to 3,000,000 cubic feet in individual wells.

Regional metamorphism in the interior of Boyd County is relatively high being indexed by the 60% isocarb which circles Cannonsburg as a center. The anomalous cause of this island of high regional metamorphism in northeastern Kentucky is unexplained. A volume of several million cubic feet open flow of natural gas is now at the casing head in Boyd County. Rock pressures vary from 350 pounds in the Salt sand, to 800 pounds in the Gordon and the Ashland gas sands. It is used locally for both industrial and domestic purposes. This gas production is derived chiefly from the three separate and somewhat irregular Ashlands "sands" encountered in the black Ohio shales (Devonic) at depths ranging from 1800 to 2200 feet.



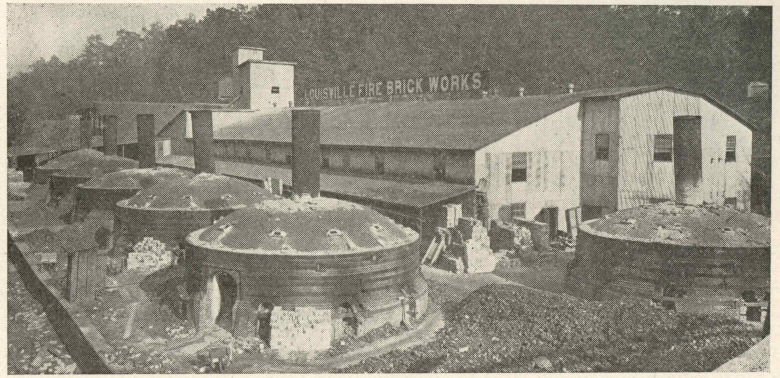

EASTERN KENTUCKY FLINT FIRE CLAY FIELD

This sketch map shows in outline the known extent of the high grade flint fire clays of the northeastern part of this State. The black dots show the locations of some of the most important mines and prospect openings. Prepared from personal field examinations and notes by the writer, correct to Jan. 1, 1926. Meridian lines indicate true North and South.

# XXI.

## FIRE CLAYS OF NORTHEASTERN KENTUCKY*

The close of the first quarter of the Twentieth Century is an interesting point from which to survey the development of the fire-clay industry of northeastern Kentucky. Twenty-five years ago these flint and semi-flint fire clays of the Olive Hill district and the plastic fire clays of the region immediately to

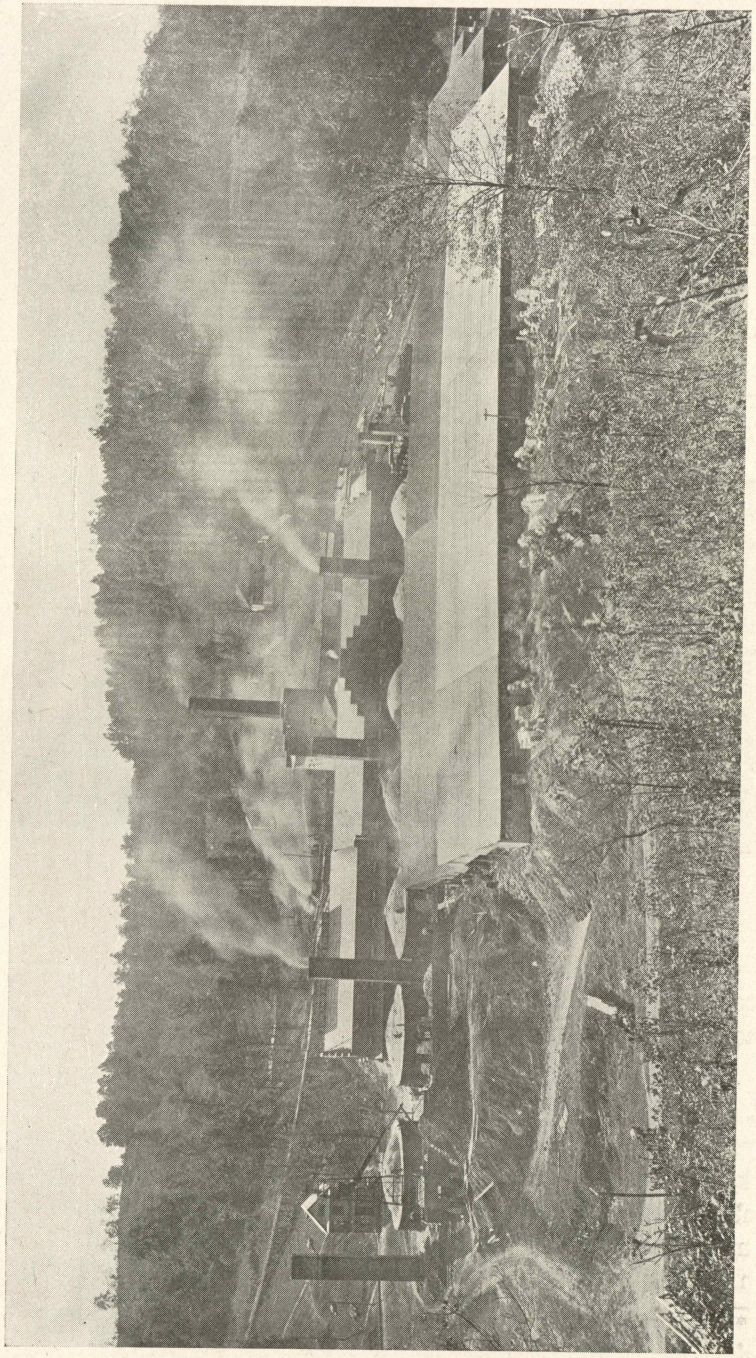



LOUISVILLE FIRE BRICK WORKS, WITH DAILY OUTPUT OF 50,000.

the east adjoining Ashland were known and operated. Their discovery belongs to a chapter more remote in the history of mineral development of Kentucky.

Long before railroad construction between Ashland and Mt. Sterling made it possible to produce and operate the fire clays they had been described in the official reports of the Kentucky Geological Survey. In the latter part of the Nineteenth Century a real effort was made to reach them with adequate transportation, and with the completion of the Lexington division of the Cincinnati & Ohio Railroad, about 1883, the first flint

* Reprinted with revisions from the Manufacturer's Record, Baltimore, Md., Jan. 28, 1926, as Ky. Geol. Survey, Series VI, Pamp. VIII, 9 pp., 1926.



HAYWARD PLANT OF ASHLAND FIRE BRICK CO., WHICH PRODUCES AT THREE PLANTS 30,000,000 BRICK ANNUALLY.



fire clays found their way to the outside markets. Little was done, however, to exploit these large and superior deposits of flint fire clay for many years.

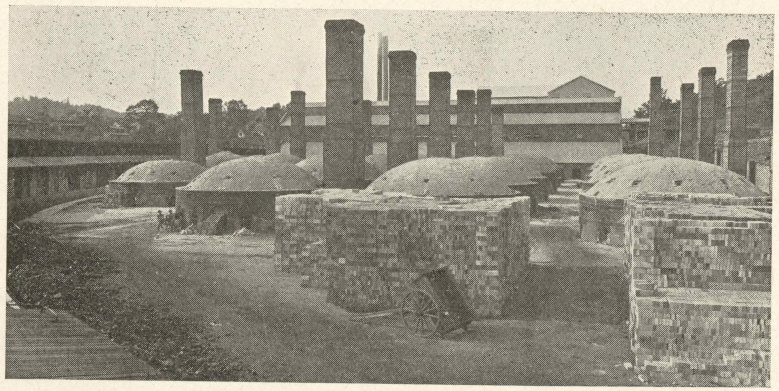
In 1900 the volume and value of all the clay products produced in Kentucky was only $1,349,827, and the volume of the fire-clay industry was so small as to preclude individual consideration in the reports of the United States Geological Survey. In 1902 not more than 17,562 tons of crude fire clay were produced, valued at $11,256. From this humble beginning the industry has grown until today the fire-clay products of the state are worth $5,082,679, based on a production of 120,053,000 brick. The rapidity of growth is well illustrated by the fact that a decade ago, in 1914, these products were valued at $1,075,158. In 1923 the number had risen to 84,977,000 brick, valued at $3,958,244. Kentucky produced fire-clay products it is thought will soon be worth something in excess of $6,000,000 annually. In 1914 Kentucky became fourth in the production of fire brick in the United States, and has maintained this position consistently, though faced by strong competition and although considerably removed from the large markets of consumption.

The Olive Hill district is the chief fire-clay producing region of northeastern Kentucky; it embraces western Carter, eastern Rowan, eastern Lewis, western Greenup and northwestern Elliott counties. Crude fire clay and brick production, however, is confined to a much smaller district, consisting of the territory immediately accessible to the Chesapeake & Ohio Railroad and its connection in Carter and Rowan counties. At present the occurrence of the high-grade flint fire clays of this district and plastic clays of the Ashland region farther east is well and generally known.

Stratigraphically these flint fire clays occur in Kentucky at the line of disconformity between the Mississippian and Pennsylvanian sediments. They are of Lower Coal Measure age (Pottsville). The heavy sandstone above them in the Olive Hill district is probably the same as the Massillon of Ohio and the upper Conoquenessing of Pennsylvania. This would make the overlying coal the same as the Anthony of Ohio and place the clays about midway between the Sharon or No. 1 and the

Quakertown or No. 2 coal of Ohio and Pennsylvania. These clays are the same as the Sciotoville flint fire clays of Southern Ohio upon which a very important fire brick industry at Portsmouth and Sciotoville has flourished since about 1864.

Prospecting has been done over a wide territory, indicating the general delimitations of the field, which extends in a northeast and southwest direction from the vicinity of the Ohio River southwestward into northern Morgan and Menifee counties. The



OLIVE HILL PLANT WHICH PRODUCES DAILY 90,000 BRICKS.

territory consists of about 600 square miles, much of which, however, due to erosion, is not underlain with flint fire clay. It is estimated that the area of actual flint fire clay might be perhaps about 25 or 30 per cent. of the territory indicated. In the Ashland district the plastic clays are found outcropping over a broad territory, the area of which, including parts of Greenup, Carter and Lawrence counties, is estimated to be about 80 or 100 square miles.

The best plastic clay of the Ashland district occurs with the Vanport or Ferriferous limestone [1] near the base of the Allegheny. This clay is mined and burned in the vicinity of Ashland. The horizon is not difficult to locate or follow in the field, and many opportunities for the development of this particular clay are afforded at points adjacent to good rail transportation. It frequently exhibits flint lenses.



The increasing demand during the last few years for high quality flint fire clays has been developed largely by an increase in the metallurgical industries. In northeastern Kentucky the rapid increase in development of the flint fire clays has resulted from a normal expansion of industry in the United States. It has been advanced also by the work out of mines in the northern Appalachian region. Since both of these factors must continue, the prospect for the expansion of the industry during the next decade is very bright. At present about a dozen plants are in operation. Several parties are engaged in field work by various companies outlining accessible and reserve deposits in Carter and adjoining counties.

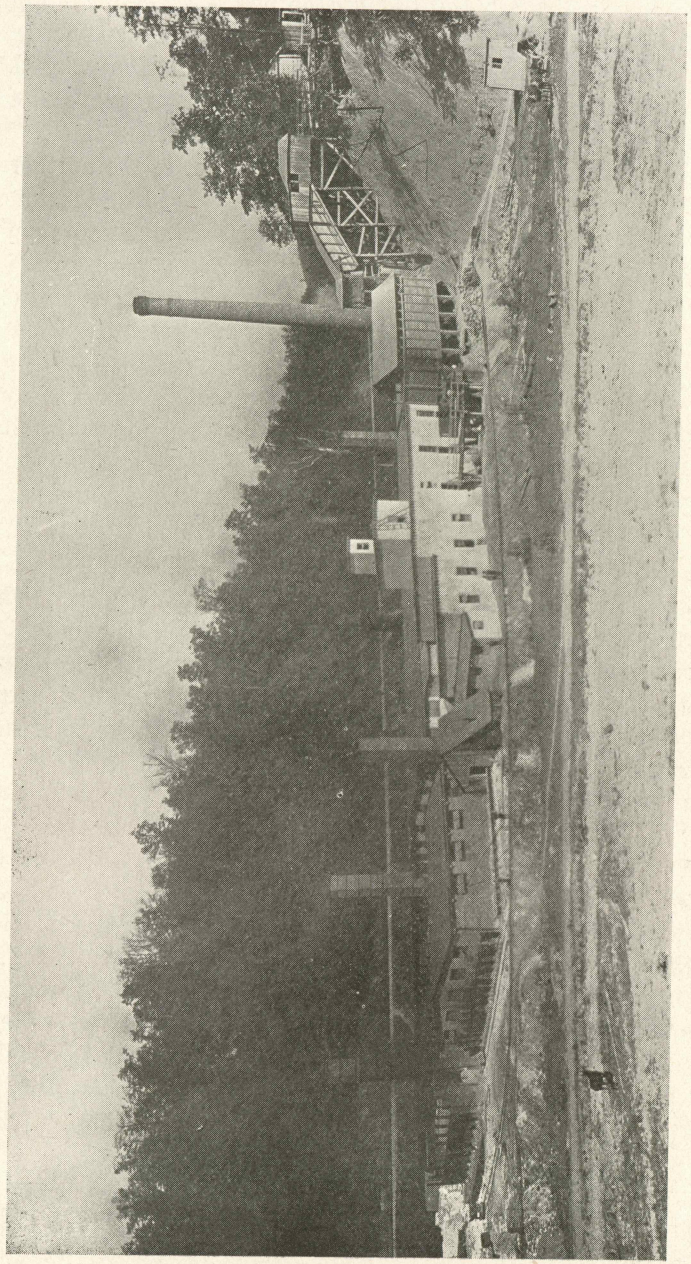
It is apparent that Kentucky has to offer to the industry virgin flint fire clay deposits of high quality and large quantity broadly distributed. Short extensions from operating trunk lines will serve in most cases to open up these almost immediately accessible reserves and afford operating and manufacturing opportunities in the fire-brick industry of the first order.

The growth in number and capacity of production of the plants manufacturing fire brick for superior grade in this northeastern Kentucky flint clay field has been remarkable during recent years, and the prospect for further immediate enlargement of this important industry is very good. About 75 mines and commercially important prospects are operating or ready for operation at the present time in this district. The following fire brick plants are now operating:

1. Ashland Fire Brick Co., Ashland, Boyd Co., Ky. (2 plants). 2. Ashland Fire Brick Co., Hayward, Carter Co., Ky. 3. Clearfield Clay Products Co.,[2] Morehead, Rowan Co., Ky. 4. General Refractories Co., Hitchins, Carter Co., Ky. 5. General Refractories Co., Olive Hill, Carter Co., Ky. 6. Harbison-Walker Refractories Co., Olive Hill, Carter Co., Ky. 7. Kentucky Fire Brick Co., Haldeman, Rowan Co., Ky. 8. Louisville Fire Brick Works, Grahn, Carter Co., Ky. 9. Peebles Paving Brick Co., Fire Brick, Lewis Co., Ky. 10. The Chas. Taylor Sons Co., McCall, Greenup Co., Ky.

[1] Frequently also called the Hanging Rock limestone.

[2] Now producing drain tile and sewer pipe, with large flint fire clay deposits prospected and available for use with good rail transportation on property.



EASTERN KENTUCKY FIRE BRICK PLANT

This view shows one of the operations of the Kentucky Fire Brick Co., located at Haldeman in Rowan County. It has a daily capacity of about 40,000 fire bricks.

# XXII.

## THE CLAYS OF KENTUCKY*

The clay deposits of Kentucky form one of the state's richest endowments of mineral wealth. They naturally fall into four major divisions. These groupings are regional, being based logically upon the varying geology of the Commonwealth. With the single exception of the mineral waters of the state, the clays have been used longer than any other mineral resource.

The first homesteading pioneers entering Kentucky under the leadership of Daniel Boone during and closely following the Revolution sought out good deposits of brick and pottery clay, making immediate use of them.

### First Brick Houses

Colonel William Whitley, noted Indian fighter and reputed slayer of the great Tecumseh, colleague of Boone the explorer and General George Rogers Clark, conqueror of the Northwest territory, built the first fine brick house in Kentucky near Crab Orchard, Lincoln County, in the year 1786 or 1787. The clay was dug and the brick were burned on his own extensive Virginia land grant on Cedar Creek.

Other fine brick houses for that day and time, with hand carved interior trim of solid black walnut, were built shortly following in the vicinity of Barbourville, Harrodsburg, Lexington, Bardstown, and Louisville at the Falls of the Ohio River. Many of these old landmarks and some of the old hand-made pottery used in them, including that of the Whitley homestead, are still in use today, though nearly a century and a half has passed.

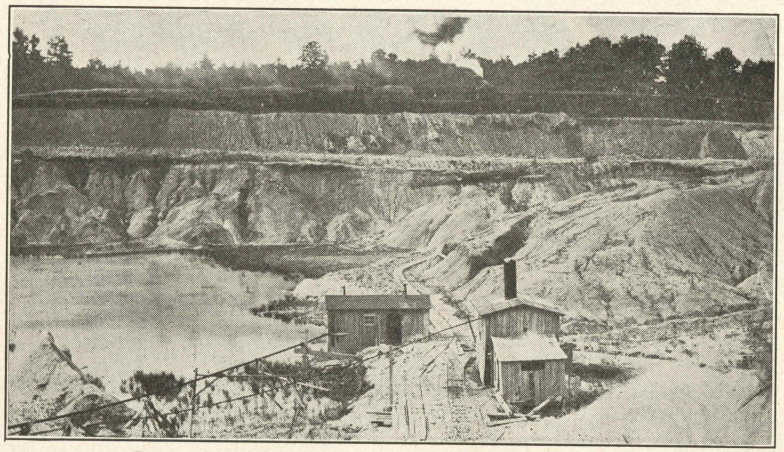
### Clay Deposits and Production

Regionally, the clays of central Kentucky are derived from both residual and alluvial deposits. The residual clays were originally calcareous shales and shaly limestones in the sequence of the paleozoic rocks of the Blue Grass, the Knobs and the

* Ky. Geol. Survey, Series VI, Pamp. IX, 15 pp., 1926. Reprinted with revisions and additions from the Ceramist, Trenton, N. J., Feb., 1926.

Pennyroyal Plateau. These deposits, with a few notable exceptions such as that of a restricted locality in Madison County where Tertiary clays are used for ornamental pottery and domestic stoneware, are confined in their source to rocks of Ordivician, silurian, Devonian and Mississippian age.

In the Waverly group (Lower Mississippian) several excellent shales, tough and red burning, are recognized and operated. Chief among these are the Rosewood shale near Louisville, the



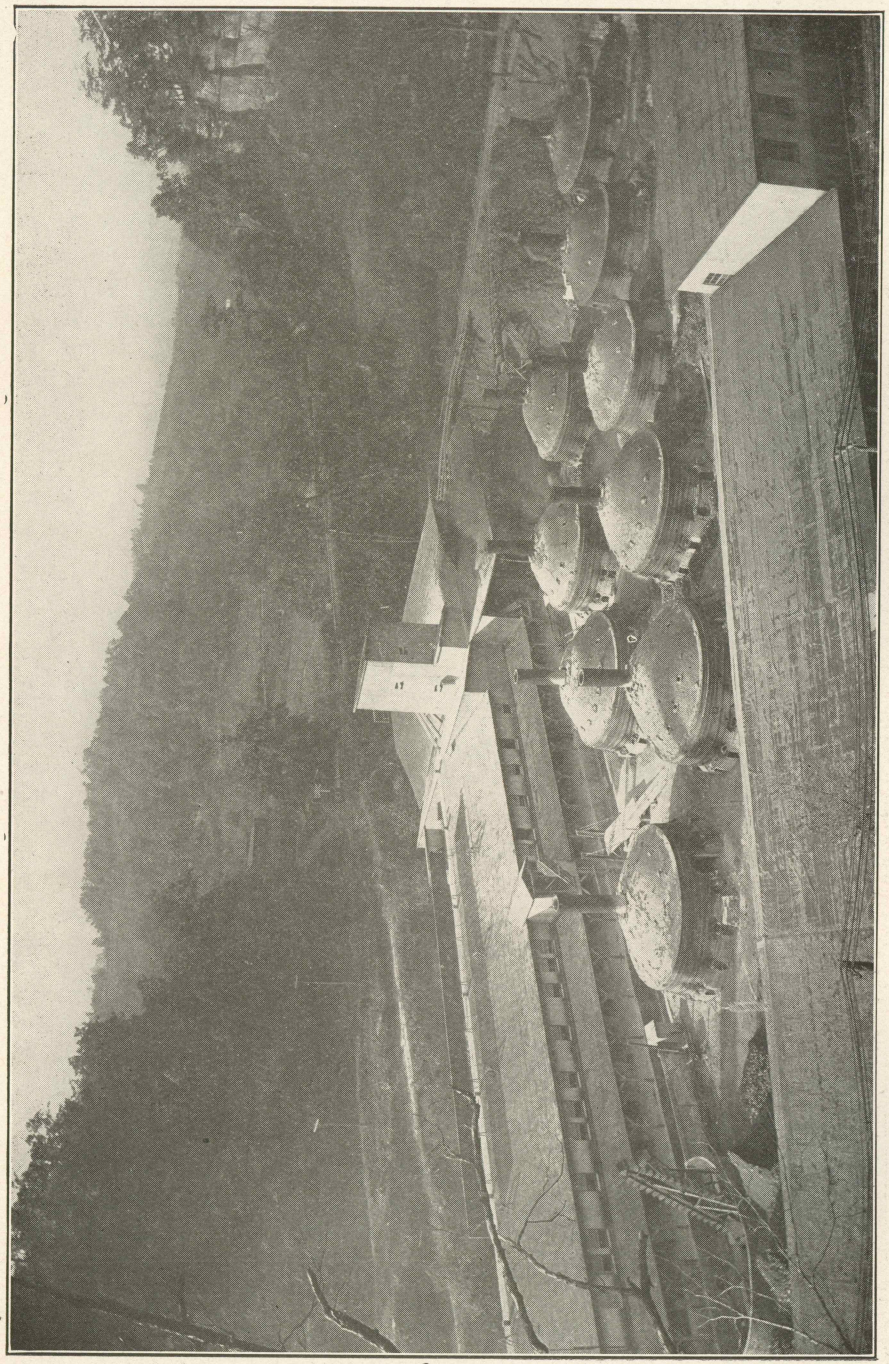
A JACKSON PURCHASE CLAY PIT

This is the operation of the Kentucky Construction and Improvement Company, at Pryorsburg in Graves County. Both sagger and ball clay are produced.

New Providence shale extending from Louisville in a semi-circle through the Knob belt to the vicinity of Stanford, and the Bedford shale found only from Irvine to Vanceburg.

The chief products produced from these clays are common and ornamental building brick, drain tile, and hollow blocks. Of lesser though considerable importance, are the floor and wall tile, sewer pipe and pottery products.

The large clay manufacturing establishments are located in the vicinity of Newport, Covington, Louisville and Lexington, though there are a number of smaller plants well distributed through the southern central part of the state, using clays of the group above described. At Maysville, on the Ohio River, surface clays of Pleistocene age are used in making building brick.



A CARTER COUNTY FIRE BRICK PLANT EAST OF OLIVE HILL

The largest unit clay producing industry of Kentucky is that built upon the deposits of flint and semi-flint fire clays of North-eastern Kentucky. These deposits are all of upper carboniferous age and are found at the line of unconformity between the Mississippian and Pennsylvanian sediments. They are mined in Rowan, Carter and Greenup Counties, and while a considerable proportion of the tonnage is delivered in the crude form outside of the state, the bulk of the flint and semi-flint clays that are produced in Kentucky are manufactured into fire brick of various kinds at or near the mines, and in Louisville, Kentucky. These products find their way into the largest metallurgical, glass-making, and other associated high thermal industries of the United States. The remainder of the Eastern coal field has few clay-working establishments though considerable deposits of clay are known to exist at various points. Common brick are manufactured near South Portsmouth, Ashland, Barbourville, Corbin, and Williamsburg.

In Western Kentucky, due to the gradual depression of the coal field in this district during late geological periods, excellent and widespread deposits of clay suitable for brick, drain tile, and sewer pipe manufacture occur. The large number of drainage projects recently under construction and projected for the immediate future have given rise to a considerable demand for drain tile in this section.

Industries supplying these and similar products are located in the vicinity of Henderson, Owensboro, Madisonville, Central City, and in adjoining areas. At Cloverport, roof as well as floor and wall tile also are manufactured.

The clays used in practically all cases are either residual from the Coal Measure (Pennsylvania) shales, or are transported silts of the Ohio, the Green or the Tradewater Rivers.

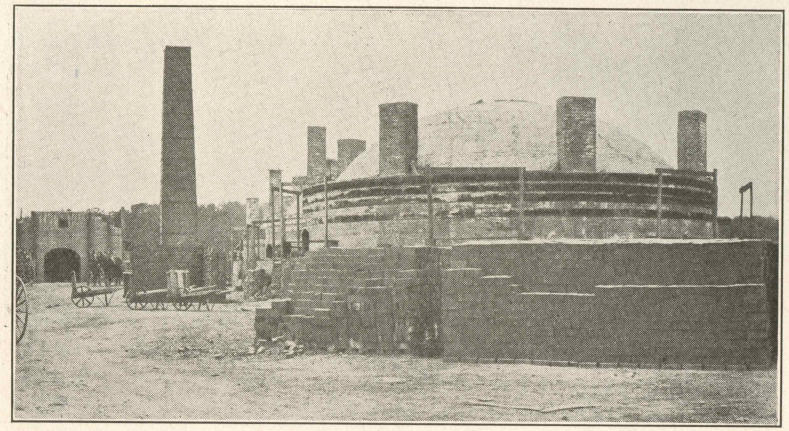
### Jackson Purchase Deposits

The Jackson Purchase comprises a unit area separate physiographically and geologically from all other portions of Kentucky. It is the northeastern portion of the old Gulf embayment. In it a considerable variety of unconsolidated Tertiary and pleistocene sediments occur. From a standpoint of ceramics, the ball and sagger clays as well as the stoneware and brick clays



are of chief importance. Large mines or clay pits are located near Wickliffe, Benton, Mayfield and Murray.

The best pottery clays are found in Calloway and Graves Counties, while a considerable pottery manufacturing industry is found near Paducah. Brick are manufactured at Mayfield, Paducah and at Clinton, but most of the ball and sagger clays operated in this section are exported to the northeast, principally into the States of Pennsylvania and New Jersey, where they are combined with other materials for high grade pottery and electrical porcelain manufacturing purposes.



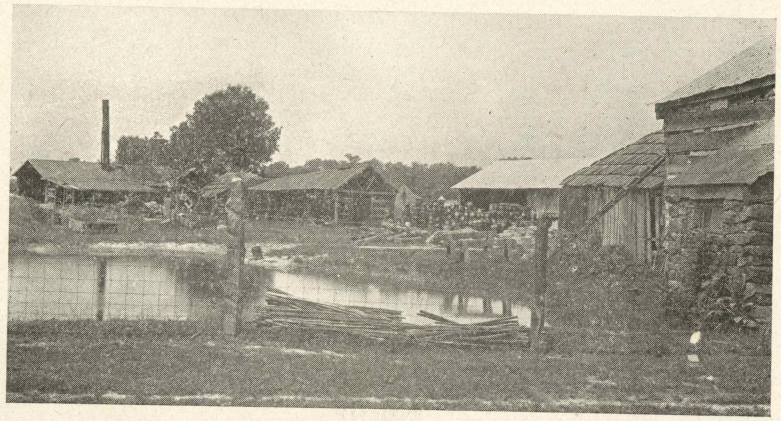
BRICK YARD AND KILN
This view shows the plant of the Standard Brick Works at Mayfield. There are many similar plants throughout Kentucky.

### Character of Deposits

Kentucky clay deposits, as this brief summary indicates, are not only widespread and variegated but are of excellent quality, no better flint or semiflint fire clays occurring in as large a quantity or in as accessible a location exist in the United States than those of Northeastern Kentucky. This field has been but partly opened. Recent coreing has shown that very considerable deposits of these indispensable industrial and metallurgical clays are existent at points somewhat removed from the railroad where they may be regarded as a flint fire clay reserve. The same statements are true in general of the residual and alluvial clays of central Kentucky. In the Jackson Purchase some of the best ball and sagger clays are only indexed by small pros-

pecting pits at points removed by several miles from present lines of transportation. These are also important clay reserves.

In the year 1924, the raw clay products of Kentucky consisted of about 231,288 tons valued at $1,000,698.00. In the year 1924 the manufactured product derived from clays of this state totaled $7,613,640.00. It is safe to say that with the development of the greater industrialism now imminent in Ken-



OLD HAND POTTERY AT BYBEE, KENTUCKY

tucky that these variegated clay deposits may be expected to respond to every need required of them and will constitute in the near future a staple mineral industry of very large extent.

KENTUCKY
MANUFACTURE OF CLAY PRODUCTS
1916 to 1925, inclusive

| Year | No. Establishments | Value |
|---|---|---|
| 1916 | 69 | $3,559,257 |
| 1917 | 55 | 5,037,636 |
| 1918 | 47 | 6,172,554 |
| 1919 | 49 | 5,711,257 |
| 1920 | 45 | 7,309,194 |
| 1921 | 45 | 4,362,094 |
| 1922 | 39 | 5,159,144 |
| 1923 | 44 | 7,676,665 |
| 1924 | 44 | 7,613,640 |
| 1925* | 50 | 8,056,425 |

* The figures for 1925 are preliminary and subject to such correction as may be found necessary upon further examination of the returns.



KENTUCKY CLAY-PRODUCTS INDUSTRIES
(Correct to 1925.)

BARREN COUNTY

Dickinson Brick and Tile Co., Glasgow, Ky.

BELL COUNTY

Rose Hill Brick Co., Pineville, Ky.

BOYD COUNTY

Ashland Fire Brick Co., Ashland, Ky.
Carter County Clay Co., Ashland, Ky.
Gates, J. J. & Co., 1500 E. Carter Ave., Ashland, Ky.
Kentucky Face Brick Corporation, Ashland, Ky.
Pittsburg Brick & Tile Co., Ashland, (Summit Station) Ky.

BOYLE COUNTY

Danville Brick Co., Danville, Ky.

BRECKENRIDGE COUNTY

Murray Roofing Tile Co., Cloverport, Ky.

CAMPBELL COUNTY

Alhambra Tile Co., 10th & Monroe Sts., Newport, Ky.

CARROLL COUNTY

Carrollton Brick Co., S. A. Grobmyer, Carrollton, Ky.

CARTER COUNTY

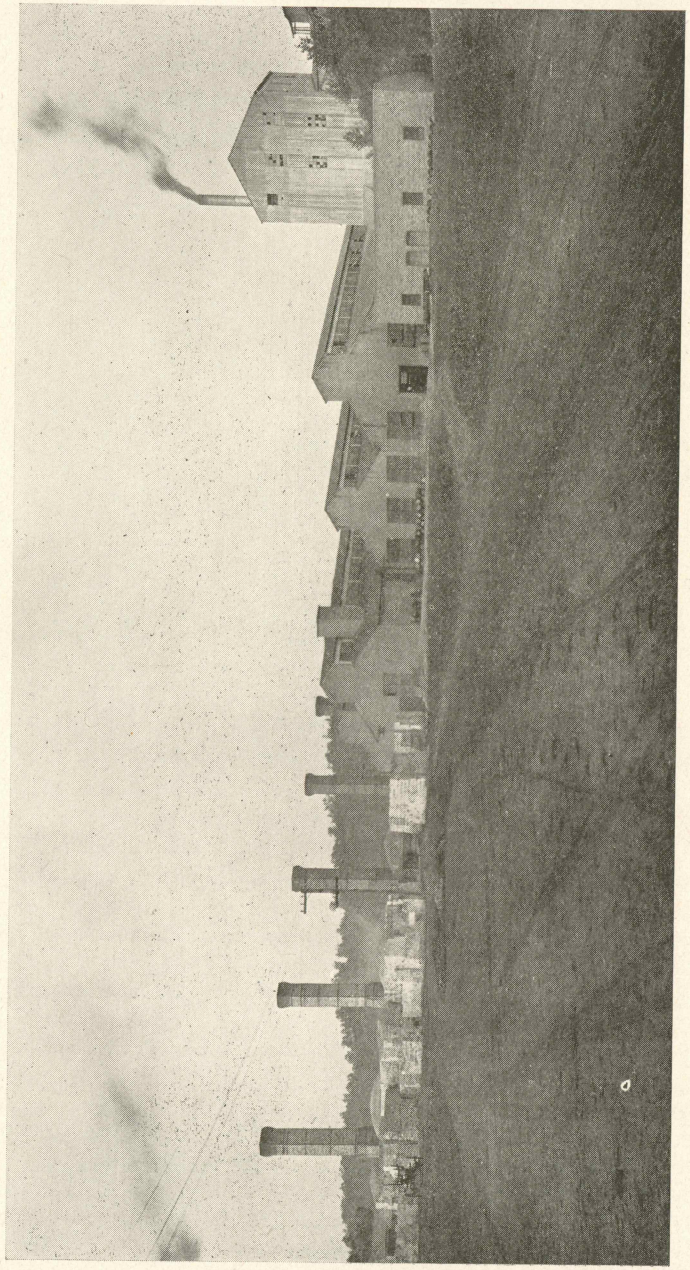
Louisville Fire Brick Works, Inc., Grahn, Ky. (Louisville, Ky.)
Ashland Fire Brick Co., (Ashland, Ky.), Soldier, Ky., mill at Hayward, Ky.
General Refractories Co. (1512 Chestnut St., Philadelphia, Pa.), Hitchins, Ky.
General Refractories Co., (1512 Chestnut St., Philadelphia, Pa.), Olive Hill, Ky.
Harbison-Walker Refractories Co., (Farmers Bank Bldg., Pittsburgh, Pa.), Olive Hill, Ky.

CHRISTIAN COUNTY

Dalton Brothers Brick Co., 129 E. 7th St., Hopkinsville, Ky.

CLARK COUNTY

Winchester Granite Brick Co., Winchester, Ky.



FIRE BRICK PLANT, HITCHENS, EASTERN CARTER COUNTY, KENTUCKY



DAVIESS COUNTY

Clark Mfg. Co., (Owensboro, Ky.), mill located at Mosleyville, Ky.
Owensboro Clay Products Co., Inc., Owensboro, Ky.
Owensboro Sewer Pipe Co., 800 Moreland St., Owensboro, Ky.

FAYETTE COUNTY

Bishop, Theophilus, Lexington, Ky.
Fayette Brick Co., Lexington, Ky.
Lexington Brick Co., New Liberty Pike, Lexington, Ky.

FULTON COUNTY

Bransford & Sons, J. H., Fulton, Ky.
Hill & Sons, W. M., Fulton, Ky.

GRAVES COUNTY

Mayfield Brick Co., Mayfield, Ky.
Kentucky Clay Mining Co., Mayfield, Ky.
Wickersham, B., (brick), Mayfield, Ky.

GREENUP COUNTY

Kentucky Refractories Co., Chinnville, Ky.
Taylor's Sons Co., The Chas. (Cincinnati, O.), McCall, Ky., mill located at Taylor, Ky.

HARDIN COUNTY

West Point Brick and Lumber Co., West Point, Ky.

HENDERSON COUNTY

Kleymeyer-Klutey Brick & Tile Works, Henderson, Ky.

HOPKINS COUNTY

Clark Mfg. Co. (Owensboro, Ky.), Ashbyburg, Ky.
Dawson Brick Co., Dawson Springs, Ky.
Hall, John W., Madisonville, Ky.
Hall, W. L., Brick Mfrs., 519 E. Broadway, Madisonville, Ky.
Madisonville Tile Co., Madisonville, Ky.

JESSAMINE COUNTY

Schoneider, A. H. & Sons, Nicholasville, Ky.

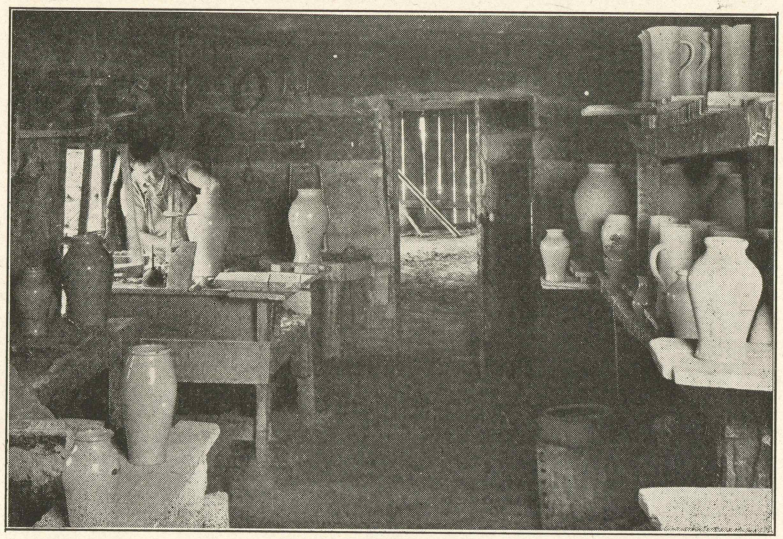
JEFFERSON COUNTY

Bannon, P., Pipe Co., 836 S. 13th St., Louisville, Ky.
Coral Ridge Clay Products Co., offices at Inter-Southern Bldg., Louisville; plant at Coral Ridge, Ky.
Louisville Fire Brick Works, Inc., 4554 Louisville Ave., Louisville, Ky.

Progress Press Brick Co., Poplar Level Road, Louisville, Ky.
Southern Brick & Tile Co., 13th and Ormsby Sts., Louisville, Ky.; plant at Whitner; P. O. at Buechel, Ky.

KENTON COUNTY

Broering & Meier, 325 W. 19th St., Covington Ky.
Busse Brick Co., Inc., 47th & L. N. R. R., Covington, Ky.
Cambridge Tile Mfg. Co., The, 1601 Woodburn St., Covington, Ky.



INTERIOR OF OLD HAND POTTERY IN MADISON COUNTY

KNOX COUNTY

Barbourville Brick Co., Barbourville, Ky.

LEWIS COUNTY

Peebles Paving Brick Co., (Portsmouth, O., Drawer 1001), Firebrick, Ky.

McCRACKEN COUNTY

Hill Karnes Brick Co., Inc., Sixth & Boyd Sts., Paducah, Ky.
Paducah Brick & Tile Co., 1439 Murrell Blvd., Paducah, Ky.

MADISON COUNTY

Richmond Brick & Tile Co., Richmond, Ky.

MARION COUNTY

Goodin Brick & Tile Co., Lebanon, Ky.



MASON COUNTY

Maysville Brick Co., office at Box 454, located at C. & O. Ry., Maysville, Ky.
Sphar Brick Co. Maysville, Ky.

NELSON COUNTY

Nelson Brick & Tile Co., New Haven, Ky.

ROWAN COUNTY

Kentucky Fire Brick Co., (Portsmouth, Ohio), Haldeman, Ky.
Gilmore Fire Clay Co., Morehead, Ky.

UNION COUNTY

Alhorn & Waller, (Morganfield, Ky.), Uniontown, Ky.
Quinn Wynn Brick Co., Sturgis, Ky.

WARREN COUNTY

Smith, C. H., 219 10th St., Bowling Green, Ky.

WEBSTER COUNTY

Providence Brick Co., Providence, Ky.

WHITLEY COUNTY

Corbin Brick Co., (Box 24, Corbin, Ky.), Woodbine, Ky.

## POTTERY ESTABLISHMENTS

CALLOWAY COUNTY

Pottertown Pottery Co., Inc., Almo, Ky. Plant at Pottertown, Ky.

FAYETTE COUNTY

Bybee Pottery Co., Inc., Lexington, Ky.

GRAVES COUNTY

Bell City Pottery, formerly W. D. Russell & Sons, Farmington, Ky.

JEFFERSON COUNTY

Louisville Pottery Co., 226 E. Bloom St., Louisville, Ky.

McCRACKEN COUNTY

Paducah Pottery Co., 7th & Trimble Sts., Paducah, Ky.

# XXIII.

## GOVERNOR POWELL'S RECOMMENDATION TO THE LEGISLATURE RELATIVE TO THE ESTABLISHMENT OF THE FIRST KENTUCKY GEOLOGICAL SURVEY*

During the nearly three-quarters of a century which has elapsed since the founding of the first Kentucky Geological Survey in 1854, many of the important incidents which contributed to this progressive step on the part of the Commonwealth have become obscure or forgotten. A brief sketch of the Survey's history was presented in the Register† in 1921, and this was followed by a more detailed historical outline issued by the Survey‡ itself in 1923.

In each of these historical accounts reference was made, of course, to the favorable action of Governor Lazarus W. Powell in approving the bill which made Kentucky's first Geological Survey an actuality. The timely aid given this project by several county and regional state agricultural and mechanical associations was of immeasurable benefit. Their combined prayers for the creation of a Kentucky Geological Survey were presented in a single printed memorial to Governor Powell. The late Dr. Robert Peter was the leading spirit in this movement, and as a result the instrument later became known as the "Peter Memorial." This communication was so well executed that it converted Governor Powell to an appreciation of the importance of the proposed Geological Survey of Kentucky.

It is interesting, therefore, to note the exact attitude taken by Governor Powell in advancing the matter through the Legislature. A critical review of his position is fortunately now made possible by the independent research of Mrs. John S. Cannon, Secretary, who in examining the executive documents recently lodged with the State Historical Society came across the

*The Register of the Ky. State Historical Society, Vol. 25, No. 74. pp. 187-189. May, 1927.

†A History of the Kentucky Geological Survey. The Register, Vol. 19, No. 57, pp. 90-112. 1921.

‡Geological Research in Kentucky. Series VI, Vol. 15, Ky. Geol. Surv., 1923.

particular message of Governor Powell having reference to this subject. Those portions pertinent to the Kentucky Geological Survey and its establishment have been excerpted and are faithfully reproduced below. Although nearly three generations have passed away since Governor Powell penned in ink these lines, much that he said still holds true. It is a sad commentary by comparison on buried talents and wasted opportunities of a great Commonwealth.

### Powell's Request of Legislature*

"The Kentucky State Medical Society at its annual meetings, has published some valuable reports on vital statistics and various other important subjects; and much good is expected to result from the circulation of the information contained in those reports among the people. I understand that the society has appointed a committee to memorialize you, as to the propriety of causing such of those reports, as you may deem of sufficient general importance, to be published with the legislative reports. I respectfully invite your attention to this subject.

"I earnestly recommend that you order a minute and thorough geological and agricultural survey of the State. Such a survey would be of incalculable benefit to the people of Kentucky. It would show the quantities, kinds and varieties of the minerals of the state and make known the geographical and geological position of the various marbles, building stones, rocks, soils, coal, iron and lead ores which abound in the state, with a chemical analysis of each, making known their utility in agriculture, in the arts, and in the manufactures. Coal, salt, saltpeter, lead, iron, marble, building stones, hydraulic limestone, etc., are found in the State, and some of them in large quantities, but their quantity, quality, variety and location are very imperfectly known. The coal fields and the iron region, each occupy, it is thought, one-fourth of the area of the State. Such a survey would collect, arrange and systematize information on this subject, and thus put a mass of certain, reliable and important information, that could not be otherwise obtained, in a shape that would make it available to all. This information disseminated

*Excerpt from manuscript message of Governor Lazarus W. Powell to the Kentucky State Legislature, recommending Geological and Agricultural Survey of the State. Dec. 31, 1853. pp. 21-24, State Archives, Ky. State Hist. Soc., Frankfort.



among the people, would give labor, employed in mining, an intelligent and certain direction, which would cause a rapid development of our vast mineral resources, and bring forth the rich mines of wealth now hidden beneath the surface of the earth, and locked up in our mountains.

"The development of the mineral wealth of the state, and the opening of abundant supplies of cheap fuel would greatly increase our manufactories, diversify labor, invite investments of capital, and make regions now sterile and worthless, prosperous and wealthy.

"There is no class of the community who have so great an interest in a geological and agricultural survey as the farmers. It would make known to them the elements of the soil, its nature, properties and capacity, in the different localities, and its adaptation to the various productions suited to our latitude and climate. Such information the intelligent farmers would appreciate and apply in such manner as to enrich their fields, increase the abundance and variety of their crops, extend the already vast agricultural resources of the state, and add to the wealth and prosperity of this numerous and enterprising constituency.

"Kentucky is far behind many of her sister states in this important matter. Almost every state in the Union has had a geological survey, and great advantages have resulted to those states, from their labors in this field of science. Without such a survey the mineral, agricultural and manufacturing resources of the state can never be fully known or developed. Our people are exhibiting laudable and praiseworthy enterprise in constructing railroads in various parts of the Commonwealth. One great object of this construction is to pierce the coal and mineral regions, for the purpose of developing their resources, and obtaining cheap, certain and lasting supplies of coal for fuel, and manufacturing purposes. Every person who has reflected on this subject, in connection with the railroad improvements now contemplated and going on in Kentucky, must have felt the want of a geological survey. It is thought that the people of Kentucky lose annually for the want of information that would be imparted by such a survey more than twice its cost. The cost of the work would be trifling when compared to the great, important and lasting benefits it would confer. You owe it to science,

to the progressive spirit of the age in which we now live, to the mining, manufacturing, agricultural and other industrial interests of the state to cause this work to be commenced without delay.''

# XXIV.

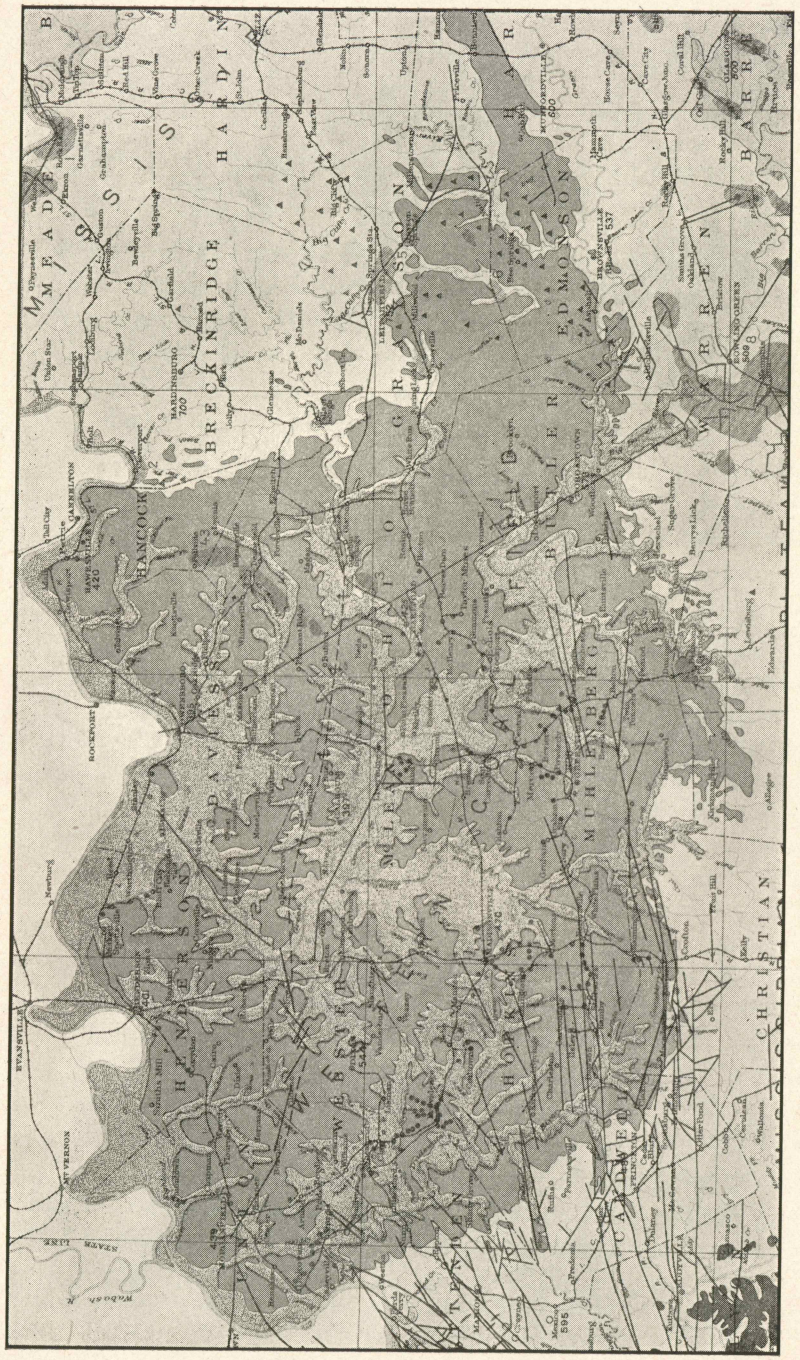
## VALLEY-FILLED AREAS OF WESTERN KENTUCKY COAL-FIELD*

Regional depression in western Kentucky has been recognized by geologists and physiographers for many years. Areal reports on small geographic units in this part of the State have discussed in more or less detail local alluviation. The completion of the topogrophic map of the western Kentucky Coal-field during the past year makes possible now for the first time a consideration of the entire region. Elevations ranging from 350 feet to about 750 feet are general. Summit levels of this maturely eroded plateau range from 650 to about 700 feet above sea-level.

Detailed field and office work indicate that in a physiographic geologic basin which is essentially coincident with the Western Kentucky Coal-field, but with some out-of-the-State extensons to the north, and covering an area of about 4,700 square miles in Kentucky there are 2050 square miles sufficiently depressed on a regional basis to allow of valley filling. Range of the elevations varies from 350 feet at the juncture of the Tradewater and Ohio rivers to 425 feet on the tributaries of the Tradewater and the Green rivers, the major drainage courses. Valley-fillings 4 to 8 miles wide are not uncommon. Well drillings and other mineral explorations in the Green River and Ohio River valleys show a maximum thickness of alluvial sediments of about 200 feet. Physiographic and stratigraphic criteria indicate this depression began in the middle, or latter, part of the Pleistocene. Subsequent uplift in a small degree is now quite thoroughly established at any points along the Green and Tradewater courses.

This regional depression in western Kentucky has had a very decided effect upon social and economic development of the area involved. Transportation both by water and overland has

* Pan-American Geologist, Vol. XLVII, No. 4, pp. 315-316, May, 1927. Presented by title before the Philadelphia meeting of the A. A. A. S., Sec. E. Dec. 1926.

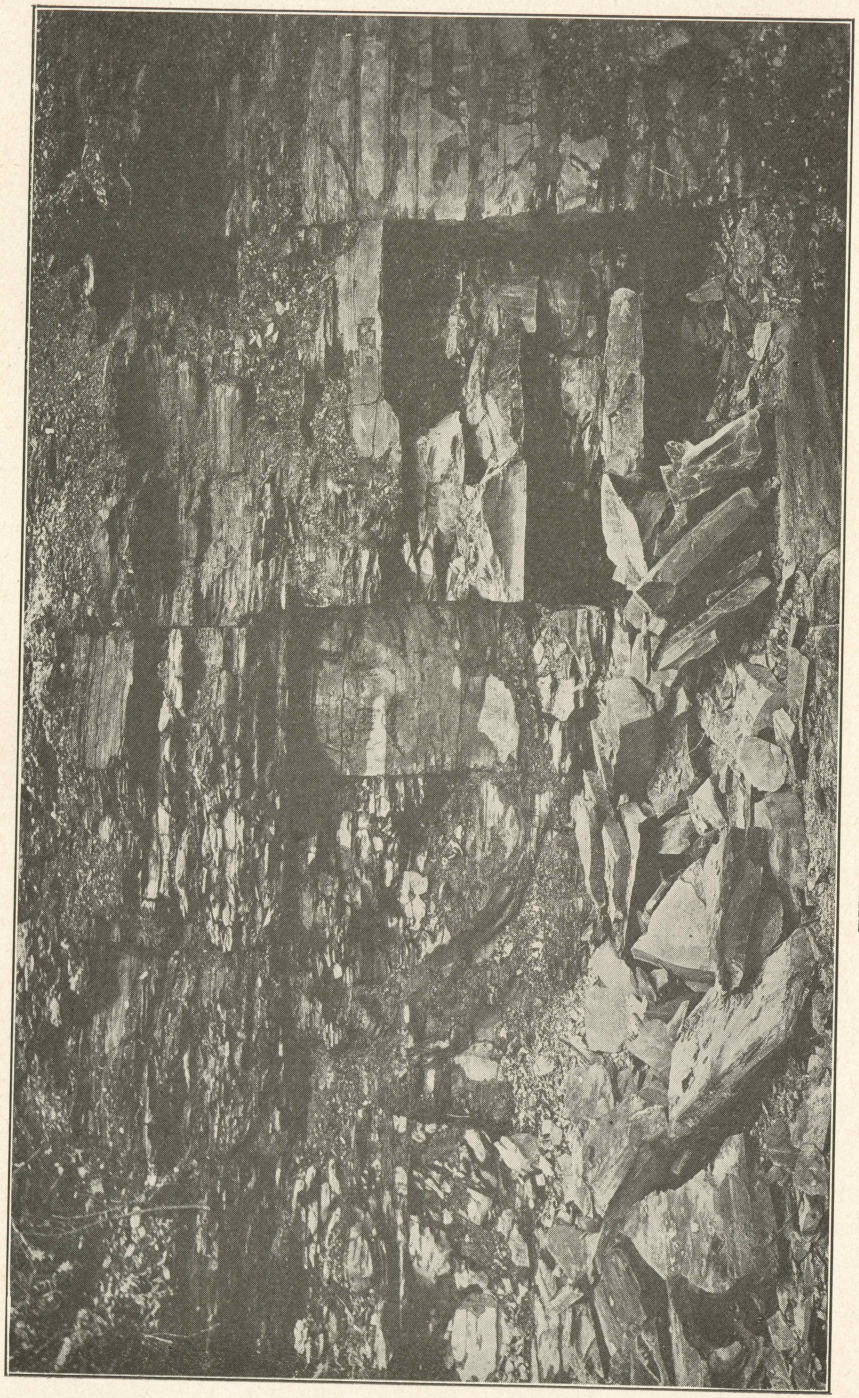



MAP OF WESTERN KENTUCKY COAL FIELD

The light areas following generally the valleys within the dark (Pennsylvanian) region represent fluviatile and lacustrine alluviation. The fault pattern is shown by dark lines.



been facilitated by low relief, but many large swamp areas are withheld from agriculture because of a lack of draining. Coal outcrops are few, though where found are frequently easily stripped. Drift-mining is almost unknown. Mineral springs are few, and oil and gas exploration is attended by indifferent success in all alluviated areas.



THE CHATTANOOGA (DEVONIAN) SHALE
These sediments are intensely black when fresh and break with a conchoidal fracture as indicated in the face of this recent exposure. This view was taken near Clay City, Kentucky.

# XXV.

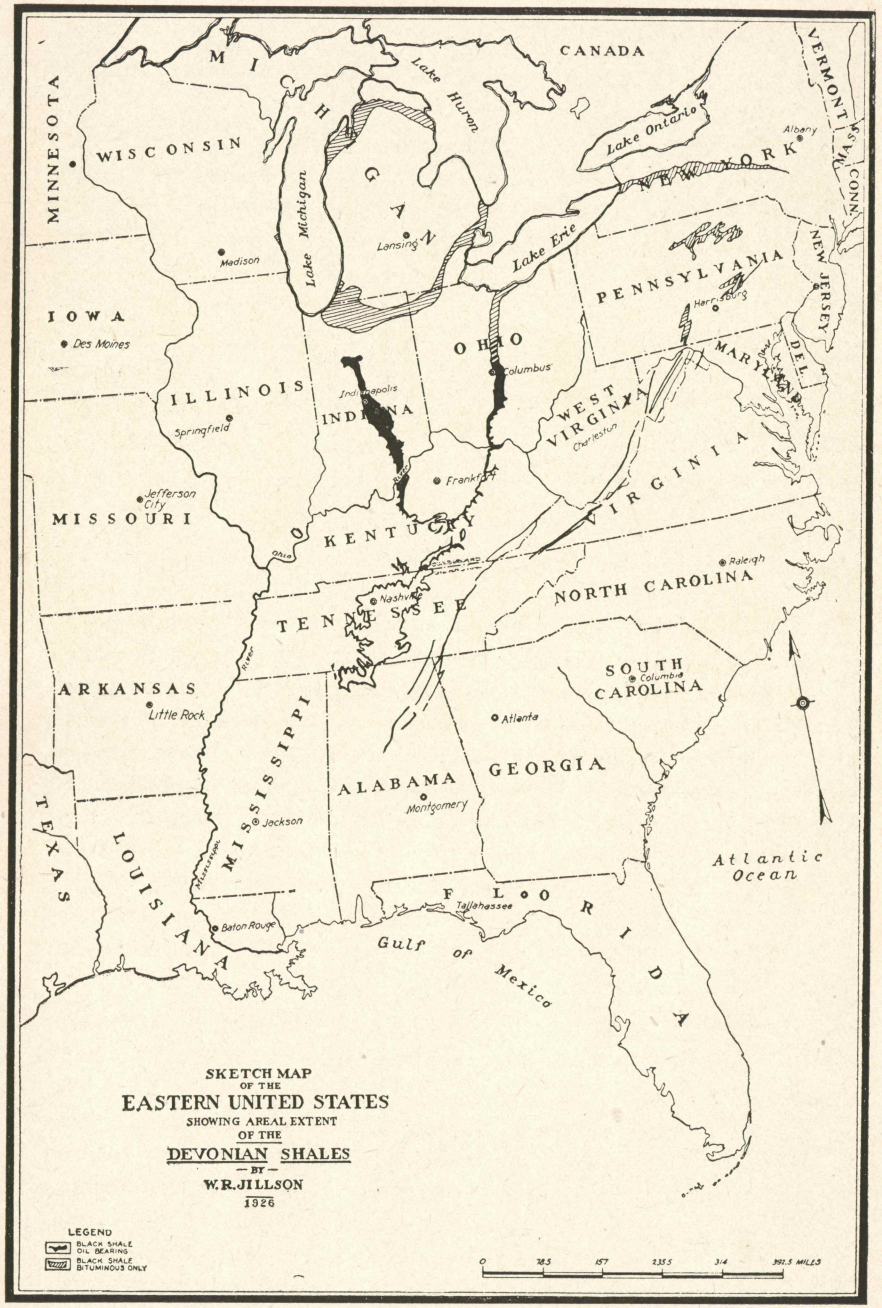
## GEOLOGY OF THE OIL SHALES OF THE EASTERN UNITED STATES*

### Introduction

Much interest has been evidenced during the past decade by European economic geologists in the petroleum reserves of the United States. As the field of productive exploration has migrated southwestward from the States of New York and Pennsylvania through West Virginia, Ohio and Kentucky to Oklahoma, Louisiana, Texas and California, speculation has been rife as to the probable source and volume of the future domestic supply of oil in the great North American republic. Even the large recent finds of Southern California and Arkansas, coupled with the excellent settled production of such well defined fields as those of Illionois, Indiana and Kansas have failed to shake the pessimistic contentions of many well informed men. It is indicated that at the present rate of about 714,000,000 barrels per annum—70 per cent of the world's annual production—the petroleum resources of the United States must soon face appreciable and permanent decline. Statistics indicate that up to January 1, 1926, the United States had produced slightly in excess of 7,900,000,000 barrels of crude oil from wells. This great volume is equivalent to about 63 per cent of all the petroleum produced in the world since the Roumanian fields were opened in 1857. It has been estimated that the known undrilled proven oil reserve of the United States contains about five and one-half million thousand barrels, which will last at the present rate of consumption for about eight years. Continued prospecting in an area of about one million acres in which petroleum in commercial quantity is possible may extend this volume of production to fifteen or twenty years or more. Though a recent report[1] on American petroleum reserves depreciates the imminency of a petroleum shortage in the United States,

* Ky. Geol. Survey, Series VI, Pamp. X, 1927. Presented before the 14th International Geological Congress personally by the writer, May 26, 1926, at Madrid, Spain

[1] American Petroleum Supply and Demand, McGraw Hill, New York, 1925.




OUTCROP OF DEVONIAN BLACK SHALES

This map attempts to show the areal extent of the Chattanooga and New Albany shales and their correlatives in the Northern States.



a perusal of the statement indicates that it savors more strongly of good pleading than of good proof.

Whether the apex of petroleum production in the United States is now close at hand or still somewhere in the more distant future time alone can tell. Decline of natural petroleum production, however, is a certainty and in anticipation of this a number of special investigations of possible substitute sources broad in scope have been carried forward during the last decade. Chief among them has been the field and laboratory examination of the bituminous shales of the United States. This work has been undertaken and advanced with such interest and enthusiasm that a very considerable body of published scientific data descriptive, analytical and statistical is now at hand in advance of any actual commercially profitable production.

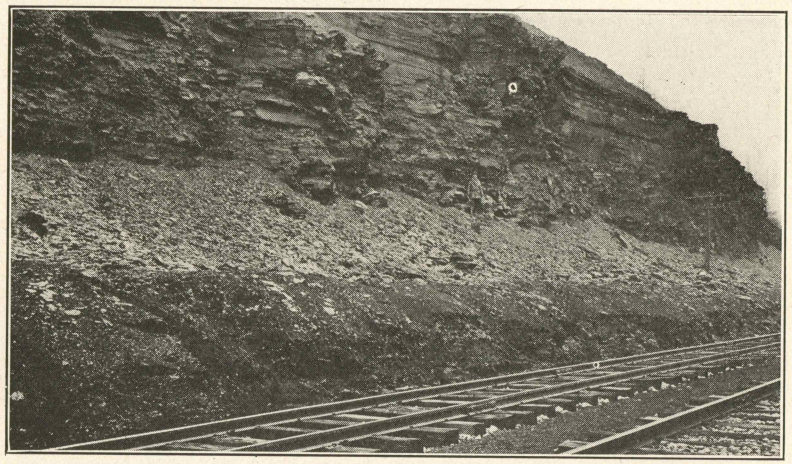
## Stratigraphic Units

Although oil shales are broadly distributed throughout the United States, particularly in the West where great thickness and richness of Eocene deposits are encountered, it is proposed to confine this paper to a discussion of the geology and some apparent economic phases of the oil shales of the Eastern United States. A number of very adequate papers and reports[2] are available on the oil shales of Western America, some of which carry the subject into great detail. The oil shales of the Eastern United States are easily divisible into three separate units or groups on a basis of their geologic age. In ascending stratigraphic sequence they are early Upper Devonian, Lower Mississippian and Lower Pennsylvanian.

The oldest and most extensive oil shale in this Eastern region is the Upper Devonion black shale of Southern Indiana and Ohio, Central Kentucky and Tennessee, and Northern Alabama. Very secondary on any basis of consideration are several lenticular bituminous shales and cannel-shales of Pennsylvanian age stretching irregularly throughout the western Appalachian Mountain and Cumberland Plateau areas. In the mid-Appalachian district and eastward they have been so altered by regional metamorphism in the course of mountain making crustal

[2] Oil Shale of the Rocky Mountain Region. D. E. Winchester. U. S. Geol. Survey Bull. 729. 1923.

movements as to be quite unfit for the purposes of oil and gas recovery by retorting methods. Though existing in great volume in the aggregate and generally somewhat richer than the Devonian shale, the characteristic thinness of these Pennsylvanian beds of oil or cannel-shale (one to four feet generally and occasionally as much as 10 or 15 feet) renders doubtful their successful commercialization possibly for some time to come. These beds under fair conditions are capable of producing from 3 to 55 gallons of raw oil or tar to the ton,[3] best laboratory retorting methods being used.



DEVONIAN SHALE, BULLITT COUNTY, KENTUCKY

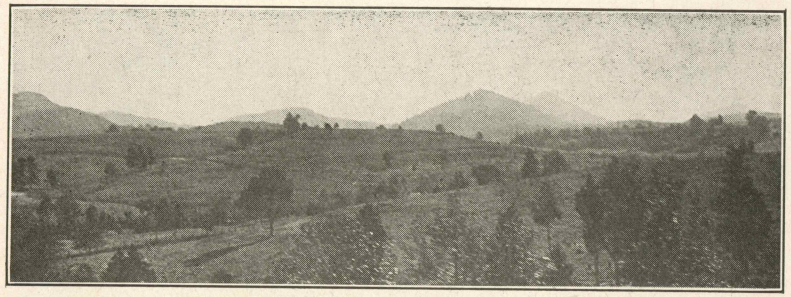
Occurring somewhat lower in the geological column, the Sunbury shale (Waverly-Mississippian) is a thinly laminated black bituminous bed ranging about 15 to 22 feet in thickness. It is the lowest and most distinctive of the Carboniferous oil shales. This unique bed is found only east of the Cincinnati Arch where the Carboniferous formations outcrop along the western edge of the Cumberland Plateau, in Northeastern Kentucky and Southeastern Ohio. Its areal extent as compared to either the Pennsylvanian or Devonian oil shales is therefore quite limited. It has produced as the result of a number of tests a maximum of 21 per cent bituminous matter.[4] An Old

[3] Oil Resources in Coals and Carbonaceous Shales of Pennsylvania, Fettke, Charles R., Pennsylvania Geol. Survey, Series IV, pp. 88-91. 1923.
[4] Geology of Kentucky. A. M. Miller. Ky. Geol. Survey. Bull. II, p. 98. 1919.



oil shale operation near Vanceburg, Kentucky, retorted this shale for paraffin but was abandoned many years ago.

The early Upper Devonian black shale is variously known as the Ohio, Chattanooga and New Albany shale depending upon its location and has been correlated with the Genesee shale of New York. Its outcrop runs southward from Cleveland and Sandusky across central Ohio, crosses the Ohio River near Vanceburg, and circling westward through Danville swings back to the northwest, crossing the Ohio River again at Louisville and

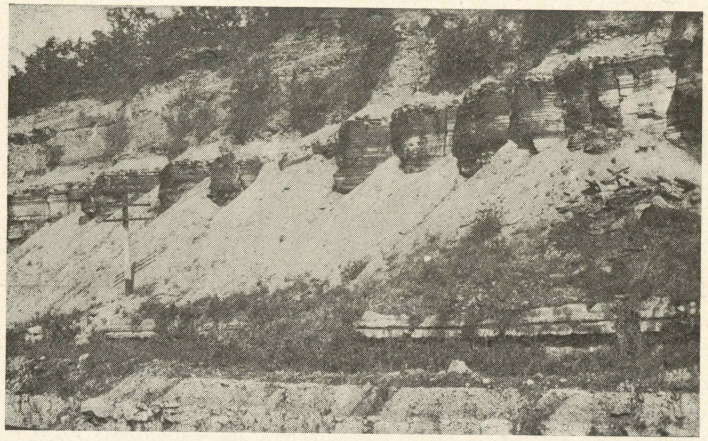


TOPOGRAPHY OF DEVONIAN OUTCROP
The view is near Panola in Madison County, Kentucky. Conical hills of oil shale capped by basal Mississippian sediments are typical.

New Albany, from which point it extends through the heart of Indiana to Lake Michigan. In Southern Kentucky it is exposed in the Cumberland River Valley and follows the highland rim of the Nashville basin of Central Kentucky with a thickness of about 30-50 feet. It reaches southward to the vicinity of Northern Alabama along the tributaries of the Middle Tennessee River and the headwaters of the Warrior River.

An extended and very irregular outcrop of this oil shale greatly thickened is found along Waldens ridge in Eastern Tennessee, Northwestern Georgia and Northeastern Alabama. This persistent bituminous formation is again found on uotcrop throughout the entire Sequatchie valley, a canoe shaped anticline paralleling Waldens ridge on the west and again in West Central Tennessee on the west flowing tributaries of the Tennessee River to the Kentucky line. In northeastern Tennessee the Chattanooga and adjacent Devonian shales ranging from 500 to 800 feet thick follow the divide between the Clinch and Holston Rivers northeastward into southwestern Virginia, where it be-

comes the lower part of the thick Kimberling shale (2000-2800 feet). This group of shale in the vicinity of Staunton, is known as the Jennings formation and has thickened to about 3400 feet. Remarkable for its continuity, this formation extends northeastward through West Virginia into Eastern Pennsylvania and Southern New York where it reaches its maximum expression in thickness though in fact it is simply a unit in a long sequence of dark to black fissile carbonaceous shales extending stratigraphically from the middle Upper Devonian (Chautauquan)



DEVONIAN SHALE IN TENNESSEE

This view of the Chattanooga black shale is found at Bakers Station on the Louisville and Nashville Railroad in northern Davidson County, Tenn. It is exposed in this vicinity over a broad area. Photo by L. C. Coleman.

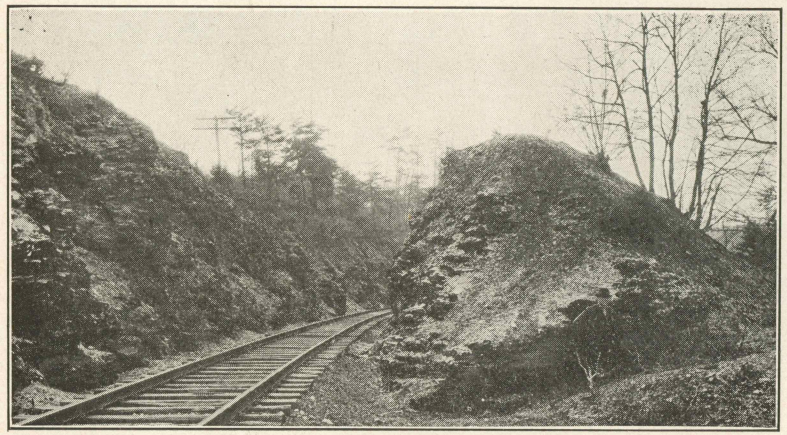
down to the lower Middle Devonian (Marcellus). In passing to the North, however, this formation at some undetermined point ceases to be in any commercial sense an important bituminous unit. Probably at no place after leaving Eastern Tennessee where 7 to 9 gallons of oil per ton[5] has been determined, is more than a very small portion of the great thickness of this formation sufficiently bituminous to be regarded as an oil shale.

Dark upper Devonian shales are found extending to the west and northwest from the type oil shale area of Southern Indiana and Ohio, Central Kentucky and Tennessee, and Northern Alabama. In Missouri these dark shales are found

[5] Oil Resources of Black Shales of the Eastern United States. George H. Ashley, U. S. Geol. Survey. Bull. 641, p. 319, 1917.



associated with some light colored shales in the central and eastern part of the State, along the lower waters of the Missouri River, and also along the Mississippi River. Adjacent to this major waterway the dark Upper Devonion shales are quite as extensive on the Illinois side, being found in the southern part of this State as far south as Pope and Hardin Counties adjoining Kentucky. Proceeding up the Mississippi River Valley to the north, Upper Devonian shales dark in color yet constantly

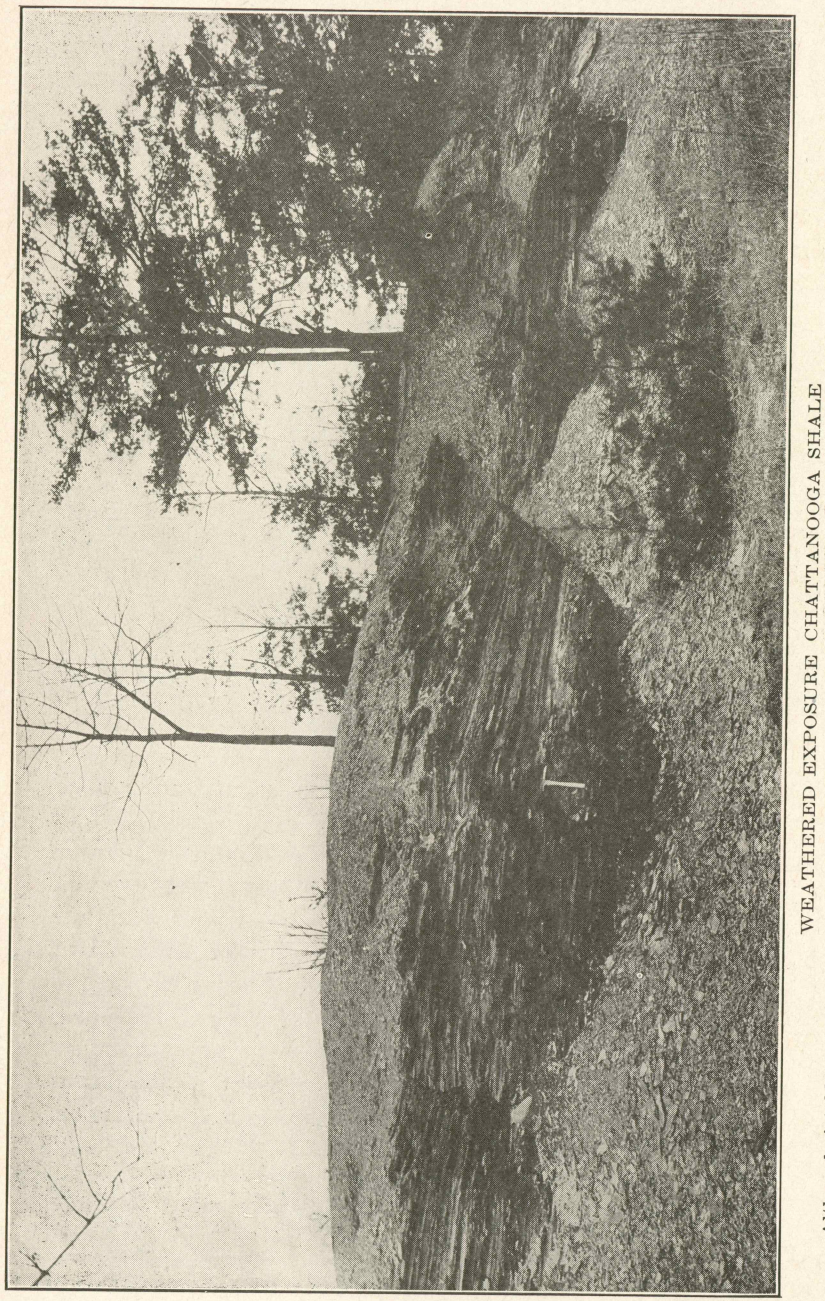


OIL SHALE, POWELL COUNTY, KENTUCKY

associated with lighter beds are found in Illinois near Rock Island and thence northwestward over a considerable belt of outcrop stretching through Iowa City, Cedar Rapids and Mason City to the Minnesota State line. Extending northwestward from the notable New York deposits, early Upper and late Middle Devonian shales stretch across the London peninsula of Southwestern Ontario, Canada, into the northern tip of the Michigan peninsula where in the vicinity of Alpena, Michigan, these argillaceous sediments are recognized to have again increased greatly in thickness and approach probably their maximum columnar expression in the Central part of North America.

## Structural Geology

The black shales of the early Upper Devonian were deposited in the Eastern United States at a time when relatively shallow waters were prevailing over a rather broad area in the



WEATHERED EXPOSURE CHATTANOOGA SHALE

Although jet black and blocky when newly opened, old surfaces of the Devonian shale as shown above weather to a brown, and form talus of paper thinness.



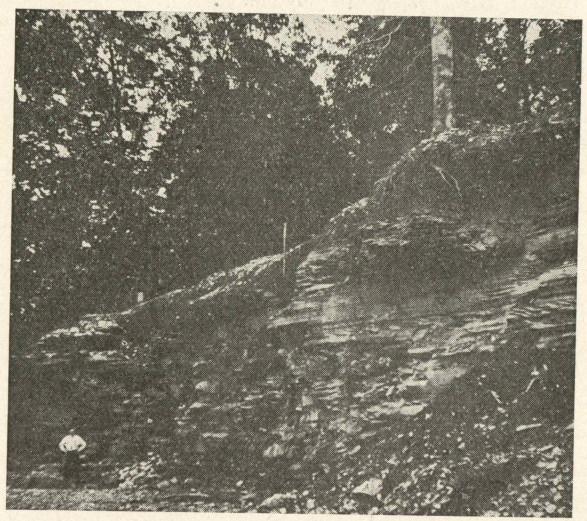
northern and southern central interior regions. Broad Arctic and Pacific connections to the northwest and west respectively have been established[6] and a restricted inlet from the Atlantic across New Jersey has also been affirmed. It is probable that southern connections with the Gulf were also made through Western Alabama and Eastern Mississippi. The gradual rising of the main axis of the Cincinnati arch is noted, these black shales thinning down very perceptibly as they pass over the top of this large regional uplift in the central interior of the Eastern United States. In some places as in Central and Western Tennessee and possibly Central Northern Kentucky insular areas appeared. In these localities the black shale is absent, and the lower Mississippian shales rest disconformably on the late Lower Devonian limestones.†

As evidence of broad, low-angle, crustal movements during the late Middle Devonian and early Upper Devonian of the central interior of the Eastern United States a comparison of some thicknesses of the Onondaga-Hamilton-Genesee sediments is illuminating. In the Blue Grass region of northern central Kentucky and central Tennessee the calcareous formations of the Onondaga and Hamilton are entirely absent. These areas are identical with the highest points of the Lexington and Nashville domes of the Cincinnati Arch. These domes were evidently islands at this time. Hamilton and Onondaga limestones of slight thickness, 10-15 feet, come in rather quickly on either side and increase to a total maximum of about fifty-five feet within short distances. The maximum thickness of the Onondaga limestone series alone at northern points considerably removed from this Kentucky and Tennessee area is about 200 or 250 feet Superimposed upon the Onondaga, the Hamilton group of sediments come in principally as coral limestones in Kentucky and Tennessee. In New York and elsewhere in the north this formation exhibits thick shale and sand components reaching a maximum thickness of about 2000 or 2500 feet. These calcareous and clastic sediments were not deposited on the top of the Cincinnati Arch which continued to exhibit twin islands throughout late Middle Devonian time.

[6] Paleography of North America. Chas. Schuchert. Bull. of Geol. Soc. of N. Amer., Vol. 20, pp. 427-606, pls. 46-101. Feb., 1910.

† Unique Devonic Sandbar. W. R. Jillson. Pan-American Geologist, Vol. XL, pp. 333-337. Dec., 1923.

Depression of slight extent occurred in the early part of the Upper Devonian and the black Chattanooga-New Albany-Genesee shale spread almost entirely over the central interior of the Eastern United States. Well upon the sides of the Lexington and Nashville domes of the Cincinnati Arch it is thinnest, and frequently no more than 20 or 30 feet are present. Some central points indicate that it may have been removed by erosion. In others it may never have been deposited. On the eastern and western flanks of these domes it rapidly thickens to 100 and 150 feet. Further away at subsurface points 75 to 125 miles from the Cincinnati Arch some new components lighter in



DEVONIAN SHALE IN INDIANA
This outcrop of the New Albany black shale occurs near Scottsburg, Indiana, and is about 100 feet thick. Photo by T. M. Kingsbury.

shade and differing in texture—possible correlative of other members of the Senacan group—come into a maximum thickness ranging from 200 to 700 feet. Careful examinations of the cuttings of deep oil and gas drillings in these removed positions reveal the fact that the characteristic jet black color of fresh samples as seen along the outcrop in the type localities is generally absent. The graying modification suggests a lowering of the high carbonaceous content found at the outcrop.

In the depths of the Appalachian geo-syncline where these sediments have been preserved from erosion thicknesses ranging



up to 1000 and more feet are known from deep drilling to be existent though fine stratigraphic distinctions naturally cannot be drawn. These great thicknesses increasing to the north extend into New York and northwestwardly into the northern tip of Michigan. Over this broad territory to the East, North and West exact and detailed correlations have never been made. It is fairly certain, however, that the Chattanooga-New Albany-Ohio shale of the type Southern Indiana and Ohio, Central Kentucky and Tennessee region is the correlative of only a small portion of the long sequence of dark to black fissile shales exhibiting an early Upper Devonian facies at points somewhat removed elsewhere.

Rather lean in fossils, paleontologists have worked on this horizon to great disadvantage. The list is complete with a few small brachiopods, a pteropod, a fish and of course myriads of plant spores. Only occasionally is a plant stem or trunk found as a silicified cast and Dadoxylon is the most frequent in occurrence. The leading brachiopods are Lingulas-brackish water forms. With these are found Leiorhynchus quadricostatus and Schizobolus concentrocus type fossils of the Genesee shale of New York. Dinychthys, a Dipnoian, is the fish most usually seen, but specimens are not common. Styliola fissurella is the Pteropod. One of the chief lithological characteristics of the early Upper Devonian black shale of this locality is its tendency to true conchoidal fracture on breaking of fresh and unweathered samples. This is due of course to its highly sporagenous content as has been shown by much detailed microscopic work on thin sections.[7]

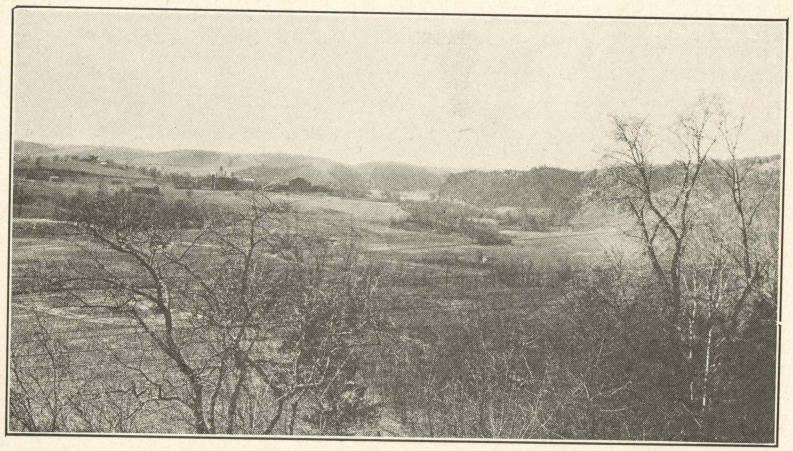
## Economics.

As the direct result of a rather considerable amount of State Geological Survey reconnaissance and laboratory detail work which has been executed during recent years in Indiana, Kentucky, Tennessee, and Pennsylvania it is possible to show the indexing value of the black Upper Devonian shale of these localities as a source for the artificial production of oil and other mineral by-products, in Kentucky an average of 19 samples indexing a specific gravity of 2.18 and a weight of 135.8

[7] Microscopic Examination of Kentucky Oil Shales. Reinhardt Thiessen. Ky. Geol. Survey, Series VI, Vol. XXI, pp. 1-58. 1925.

lbs. per cu. ft. The oil content of the same number of samples taken from the outcrop surrounding a central northern Blue Grass region of Kentucky gives an average of 16.1 gallons of oil or tar and about 7,158 cubic feet of gas per short ton.[8]

In Southern Indiana the average of a number of outcrop samples was 10.3 gallons of oil per short ton,[9] while in Tennessee such samples as were collected varied from 5 to 20 gallons per ton except in the locality of Franklin, Tennessee, where the amount of oil recovered was nearly double the maximum of



DEVONIAN SHALE BELT TOPOGRAPHY
Low hills of rounded contour are characteristic of the oil shale region where superimposed Mississippian sediments are gone.

any other point. It is stated that the average in Tennessee will be about 10 to 14 gallons per ton.[10] Throughout this district the percentage of light oils secured up to 150 degrees Fh. is about 6 to 8% though frequently samples will run as high as 30% up to 150 degrees Fh.

Proceeding away from the type localities of Southern Indiana, Ohio, Kentucky, Tennessee and Northern Alabama in all directions of known outcrop the carbonaceous content of the early Upper Devonian black shale decreases—in some localities rather rapidly, giving some certain indication that the relatively

[8] Preliminary Report on the Oil Shales of Kentucky. Willard Rouse Jillson. Kentucky Geological Survey, Series VI, Vol. II, Paper No. 1, pp. 1-37. 1921.
[9] Oil Shales of Indiana. John R. Reeves. Dept. of Geology, Indiana Univ. Mim. Pub., p. 37. 1925.
[10] Notes from Unpublished Mss. of J. H. Swartz on Devonian Shale of Tennessee. Tenn. Geol. Survey through L. C. Glenn. 1925.



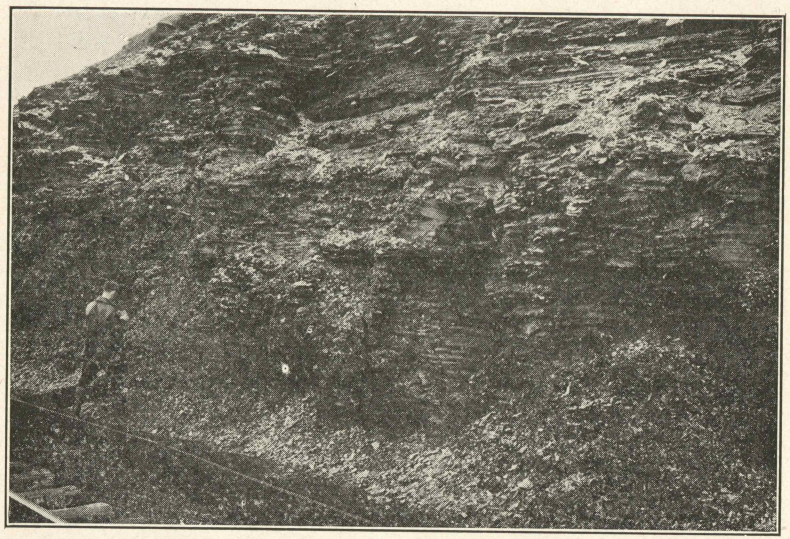
high carbonaceous content of the type locality is definitely associated with the high points along the axis of the Cincinnati anticline. Such shales of early Upper Devonian age as have been sampled at points somewhat distant from the type locality adjacent to central Kentucky and Tennessee are but very slightly productive of oils if at all, the inference being that in the deeper waters of these outlying areas conditions were not well adapted to prolific life either in plant or animal form.

It is estimated that in the type locality of Indiana, Ohio, Kentucky, Tennessee, and Alabama close to the outcrop and within the area of relatively high oil content there is probably a conservative 275,500,000 thousand of tons of Upper Devonian black shale available at the surface. Assuming a mining operating loss slightly in excess of 30 per cent there is at hand in this district 200,000,000 thousands of tons of oil shale suitable for artificial oil production. Assuming further a low average oil content of 13 gallons to the short ton, this amount of oil shale should produce under best retorting methods a conservative 60,000,000 thousands of barrels of 42 gallons each of artificial petroleum—enough oil at the present rate of consumption to last the United States upward of 100 years. This calculation does not take into account any of the several possible additional by-products which if enumerated would represent enormous values and volumes.[11]

At the present time though many plans are being projected for plants in this locality, particularly in Kentucky which is in many ways admirably located close to the heart of the population of the United States, intricately traversed by adequate railroad, highway and river lines of transportation, there are no oil shale operations. Furthermore it is not probable that any will be successfully operated in this district until a somewhat stronger market for natural petroleum develops whereby a price sufficiently large to allow the profitable production of artificial oils is made possible. By way of recapitulation it seems probable that the Black Devonian oil shale of the type locality in Southern Indiana and Ohio, Central Kentucky and Tennessee and Northern Alabama will afford the principal reserve of artificial petroleums for the Eastern United States during the

[11] An Economic Study of the Black Devonian Shales of Kentucky. Charles Stevens Crouse. Ky. Geol. Survey, Series VI, Vol. XXI, pp. 58-97. 1925.

infancy of this probable new industry. At some later time with an advancing market the Sunbury shale in the lower Mississippian and the various oil shales and cannel-shales of the



OIL SHALE NEAR JUNCTION CITY, KENTUCKY

Pennsylvanian throughout the western Appalachian Mountain and Cumberland Plateau region, where not adversely affected by high regional metamorphism, will become important artificial oil producing reserves.

*Manuscript completed March* 1, 1926.

# INDEX


A

Abandoned Meanders ..... 36
Agricultural Perspective .... 143
Allegheny Formation ..... 157
Alluviation ..... 12
American Karst Country .... 111
Antecedent Stream ..... 20
Appalachian Plateau ..... 61
Ashland Gas Field ..... 245
Asphalt Rock .....95, 96
Assistant Geologists ..... 174
Assistants, temporary ..... 175
Available maps and reports 204

B

Base Mapping ..... 105
Bibliography of Topography 57
Big Bone Lick ..... 91
Big Clifty ..... 100
Big Sandy River ..... 241
Blue Grass, The ..... 47
Blue Grass Region ..... 143
Blue Lick ..... 91
Bound Volumes ..... 187
Bowling Green ..... 114
Branner, J. C. ..... 64
Breaks of Sandy ..... 20
Bucher, W. H. ..... 67

C

Canadian Geological Survey ..... 140
Cannel Coal .....83, 84
Chattanooga Shale ..... 274
Cheatham Co., Tenn. ..... 71
Clays of Kentucky ..... 255
Clay Products ..... 260
Clay Product Industries .... 261
Conemaugh Formation ..... 158
Correspondence ..... 196
Crab Orchard ..... 91
Cretaceous Time ..... 3
Cumberland Falls .....90, 230
Cumberland Gap ..... 28
Cumberland Gorge ..... 224
Cumberland Mountain ..... 27
Cumberland Plateau ..... 241
Cypress Sandstone ..... 98

D

Dawson Springs ..... 91
Deltas ..... 14
Devonian Black Shales, 276, 280
Dripping Springs Escarpment ..... 116
Dunes, River bottom ..... 4

E

Early Glaciation in Kentucky ..... 137
Earthquake Lake ..... 18
Eastern Kentucky coal field 159
Eastern Kentucky Glaciation ..... 127
Edmonson County ..... 102
Entrenched Meanders .....25, 29
Entrenched Meandering Streams ..... 33
Epworth Boulder, 127, 130, 131, 135
Erosion Cycles ..... 22

F

Farmers Boulder .....132, 133
Fault Lines ..... 41
Fault Pattern .....77, 78
Federal Asphalt Mine ..... 99
Field Work ..... 185
Fields, W. J., Gov., Recommendations of .....219, 220
Fire Clays ..... 249
Flint Fire Clay field ..... 248
Fohs, F. J. ..... 63

G

Galloway, J. J. ..... 75
Gardner, J. H. ..... 61
Geologic Aides ..... 175
Geographers ..... 175
Gill, A. C. Professor ..... 62
Glacial Pebbles ..... 123
Glaciation ..... 38
Glasgow Junction ..... 113
Golconda Limestone ..... 100
Golconda Plateau ..... 53
Governing Statutes ..... 173
Great Crystal Cave ..... 118
Great Onyx Cave ..... 119
Gulf Embayment Region .... 87

H

Hanging Valley ..... 42
Harpeth River .....71, 72
Harrods Creek ..... 6
Highway Department Resolution .....202, 203
Hydro-Electric Development 192

I

Index to Structure ..... 179
Index to Topography ..... 48
Inner Bluegrasses Area ..... 147

J

Jackson Purchase Claypit.... 257
Jackson Purchase Deposits 258
Jeptha Knob .....67, 144
Jillson, W. R. .....174, 183
Junction City ..... 290

K

Karst Region .....8, 152
Karst Topography ..... 46
Karst Tracts ..... 112
Kemp, Prof. J. F..... 62
Kentucky Geosyncline ..... 157
Kentucky Mountains ..... 156
Kentucky River Gorge .....2, 23
Kentucky State Park Commission ..... 225
Knobs Escarpment ..... 170
Knobs Features ..... 150
Knobs, The ..... 47
Knobs Topography ..... 21
Kyrock, Ky. ..... 102

L

Lake Shores ..... 38
Late Youth ..... 9
Lexington ..... 8
Lexington Plateau ..... 148
List of Available Reports.... 204
Lost River ..... 114
Louisville Plain ..... 166

M

Mammoth Cave .....87, 111
Mammoth Cave Region ....3, 117
Mather, Dr. W. W. ..... 81
Mature Dissection ..... 11
Mature Topography.....8, 10, 20
Maturity ..... 10
Mineral Production ..... 107
Mineral Resource Production ..... 190
Mineral Springs ..... 273
Mississippi Plateau, 48, 151, 152, 168
Mississippi River ..... 4
Monticello ..... 114
Mountains, The ..... 47
Mt. Vernon ..... 114

N

Natural Bridge .....7, 222
Natural Bridges .....6, 93
Natural Resources ..... 231
New Bound Publications .... 186
New Madrid Disturbance.... 18
New Maps ..... 184
Norwood, Prof. C. J. ..... 95

O

Office Work ..... 195
Ohio Lowlands ..... 162
Ohio River ..... 4
Ohio River Bottoms ..... 160
Ohio River Lowlands ..... 5
Oil Shales ..... 275
Old Age .....12, 26
Outer Bluegrass Region ..... 147
Owen, Dr. David Dale .....44, 95
Ozark Mountains ..... 61

P

Pedestal Rock ..... 6
Pennyroyal Region ..... 151
Personnel of Survey ..... 174
Peter, Dr. A. M. ..... 101
Physical Properties ..... 190
Pine Mountain .....19, 40, 241
Pineville Gap ..... 39
Poindexter, O. F. ..... 131
Ponded Sink Holes ..... 120
Postage Receipts ..... 198
Powell County ..... 7
Powell, Gov. Lazarus W., recommendations of ..... 267
Publications Distributed .... 197
Purchase Region ..... 164

Q

Quadrangle Distribution .... 44

R

Recent Surveys ..... 49
Recommendations to Governor ..... 199
Reconnaissance Map ..... 214
Reconnaissance Topography ..... 46
Reelfoot Lake ..... 17
Regional Fill ..... 12
Regional Uplift ..... 43
Relief Map of Kentucky .... 81
Renshawe, John H. ..... 81
Ridge, Cliffs ..... 29
River Terraces ..... 14
Rock Asphalt .....95, 96, 97
Rock Asphalt Quarry ..... 216
Russell Fork ..... 8

S

Safford, J. M. ..... 74
Serpent Mound ..... 67
Sink Hole Topography 114, 115
Sink Hole Tracts..... 112
Sixth Geological Survey .... 173
Smith, L. B. ..... 62
Soil Formation ..... 145



Stalactites ..... 87
State Parks ..... 221
Stratigraphic Units ..... 277
Stream Adjustment .....29, 30
Stream Erosion ..... 8
Stream Lakes ..... 15
Stream Piracy ..... 25
Structural Geology ..... 281
Summit ..... 103

T

Tar Springs Sandstone ..... 99
Tomlinson, W. H. ..... 131
Topographic Effects of Ground Water ..... 33
Topographic Mapping ..... 188
Topographic Index ..... 48
Topographic Sheets ..... 215
Topography ..... 1
Topography of Karst Area 34

U

United States Geological Survey ..... 44
Unused Natural Wealth ..... 235

V

Valley Fill ..... 13
Valley Filled Areas ..... 271
Variable Rock Harness....19, 54
Versailles ..... 8

W

Wells Creek Basin ..... 67
Western Kentucky Coalfield 19, 163, 272
Williams, J. F. ..... 64
Wind Erosion ..... 4

Y

Youthful Stream ..... 8